CHALCANTHITE

AMMONITE

CROCOITE

SULFUR

ONYX

LACE CORAL

VARISCITE

CAROLINA HEMLOCK

PERUVIAN LILY

TRAVELLER'S TREE

PRICKLY PEAR

PURPLE CONEFLOWER

LORENTZ'S BROMELIAD

FLAME LILY

COMMON FRINGE LILY

SCARLET ELFCUP

SULPHUR TUFT

ROSY BRITTLEGILL

RED CAGE FUNGUS

LUMPY BRACKET

PENNY BUN

VIOLET CORAL

BAROMETER EARTHSTAR

THE NATURAL HISTORY BOOK

THE ULTIMATE VISUAL GUIDE TO EVERYTHING ON EARTH

ORANGE-BARRED SULPHUR

COMMON GREEN SHIELD BUG

WART-HEADED BUG

FLAME SKIMMER

GOLD BEETLE

QUEEN ALEXANDRA'S BIRDWING

FIRE BUG

ADONIS BLUE

COMMON KESTREL

ROCKHOPPER PENGUIN

PURPLE GALLINULE

PLUMED WHISTLING DUCK

SCARLET IBIS

COMMON KINGFISHER

BARN OWL

YELLOW-COLLARED LOVEBIRD

FRILLED LIZARD

STRIPED HYENA

PORCUPINEFISH

AARDVARK

CRESTED PORCUPINE

GUIANAN SQUIRREL MONKEY

TINKER REED FROG

NEW EDITION

THE NATURAL HISTORY BOOK

THE ULTIMATE VISUAL GUIDE TO EVERYTHING ON EARTH

DK

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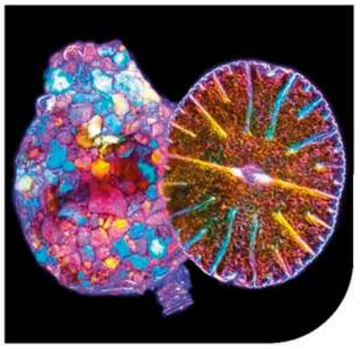

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SMITHSONIAN INSTITUTION

Established in 1846, the Smithsonian Institution – the world's largest museum and research complex – includes 19 museums and galleries and the National Zoological Park. The total number of artefacts, works of art, and specimens in the Smithsonian's collections is estimated at 155.5 million, the bulk of which is contained in the National Museum of Natural History, which holds more than 126 million specimens and objects. The Smithsonian is a renowned research centre, dedicated to public education, national service, and scholarship in the arts, sciences, and history.

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David Burnie is a former winner of the Aventis Prize for Science Books, and the editor of DK's highly successful *Animal*. He has written or contributed to more than 100 books and is a fellow of the Zoological Society of London.

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FOREWORD

When I was a boy, I would visit the local public library and spend as long as I was allowed looking at science and reference books. The books that especially enthralled me were the forerunners of this book. Packed with colour diagrams, images of exotic species, and faraway places coupled with informative text, they were the siren call for a lifetime of studying and teaching. The natural world around me was then an unknown entity and I wanted to learn about all of it. It is a very human desire to learn, but nobody knows which bit of biology they will be most attracted to and I went on to pick the largest and most diverse animal group of all. If I were to live a lifetime of lifetimes, I would never know everything there is to know about insects.

No book could ever be a comprehensive study of Earth's extant life forms, which incidentally comprise only one per cent of those that have ever lived. For that you would need a library of hefty tomes. What you have in your hands is much more serviceable. It is a clear road map to guide you on a journey that will take you from the steaming forests of the tropics to the freezing cold of the polar regions, and from mountain peaks to the depths of the ocean. It is an abridged exploration of the products of a couple of billion years of evolution that will show you some of the several million ways of living on Earth.

It is relatively easy to write screeds of detailed information on any topic you care to name, but this approach is not going to be of use to anyone other than experts and it is unlikely to encourage anyone else to study the living world. No, the real skill and the very purpose of this book is to distil a vast body of natural history knowledge amassed by countless researchers to provide an authoritative yet accessible account.

There may come a time in the distant future when we are able to venture elsewhere in our galaxy and beyond. Will we find extraterrestrial life on a far distant rocky planet and if so, will it be simple, single-celled organisms or complex creatures to rival humans or humpbacked whales? To imagine that in the vastness of the Cosmos, our inconsequential planet is the single, solitary place where life has evolved – an unbelievable fluke of stellar serendipity – seems vanishingly improbable. What is certain is that we inhabit a planet of staggering complexity and breathtaking beauty and one that is constantly changing. What we must realize, and quickly, is that we have no dominion over it but are simply part of an immense community of interdependent species.

Newcomers to natural history will find themselves engrossed and even specialists, steeped in the minutiae of one tiny part of the tree of life, will value the majestically broad sweep of this meticulously researched volume. If I could have my life all over again, I'd start by reading this.

DR GEORGE McGAVIN

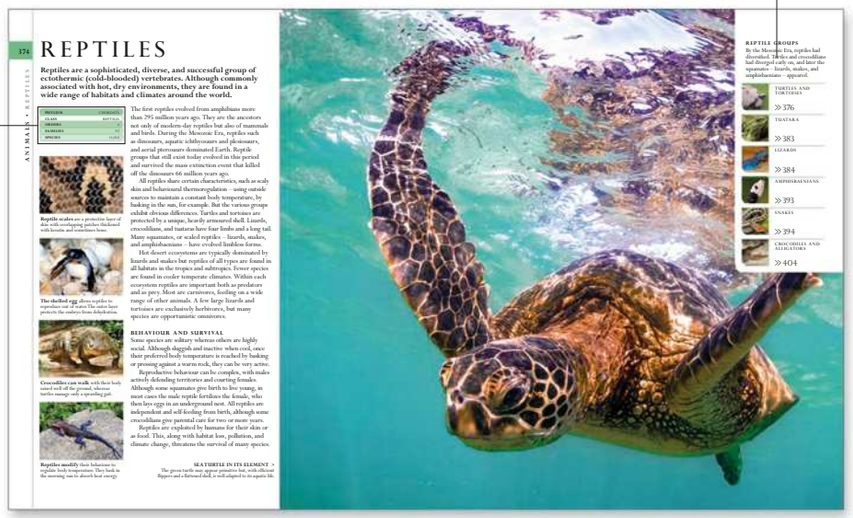
Honorary Research Associate,
Oxford University Museum of Natural History
Senior Principal Research Fellow, Imperial College London

ABOUT THIS BOOK

The Natural History Book **begins with a general introduction to life on Earth: the geological foundations of life, the evolution of life forms, and how organisms are classified. The next five chapters form an extensive, accessible catalogue of specimens – from minerals to mammals – interspersed with fact-filled introductions to each group and in-depth feature profiles.**

for easy reference, visual contents panels list the subgroups within each section, and the page number where each subgroup can be found

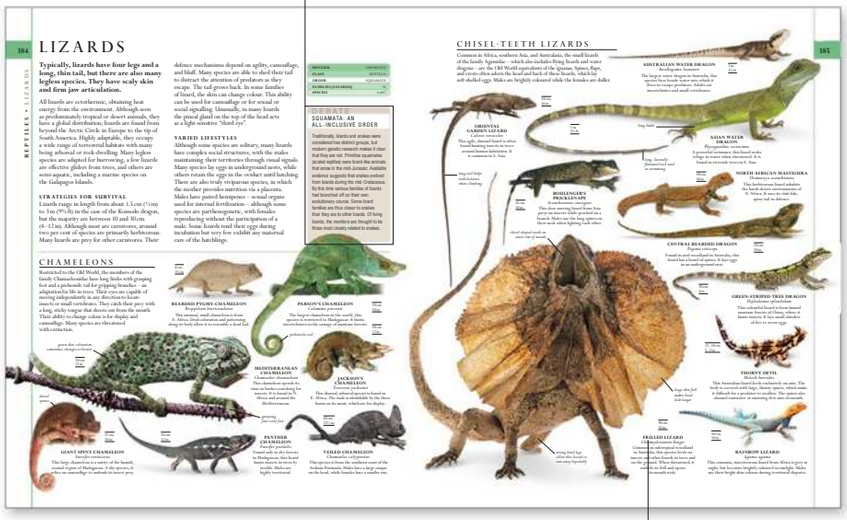
SECTION INTRODUCTION >
Each chapter is divided into sections representing major taxonomic groupings. The section introduction highlights the characteristics and behaviours that define the group, and discusses their evolution over time.



on each introduction, classification boxes display the current taxonomic hierarchy – the level of the group under discussion is highlighted

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDERS	4
FAMILIES	92
SPECIES	11,050

debate boxes tackle scientific controversies and taxonomic discussions arising from new discoveries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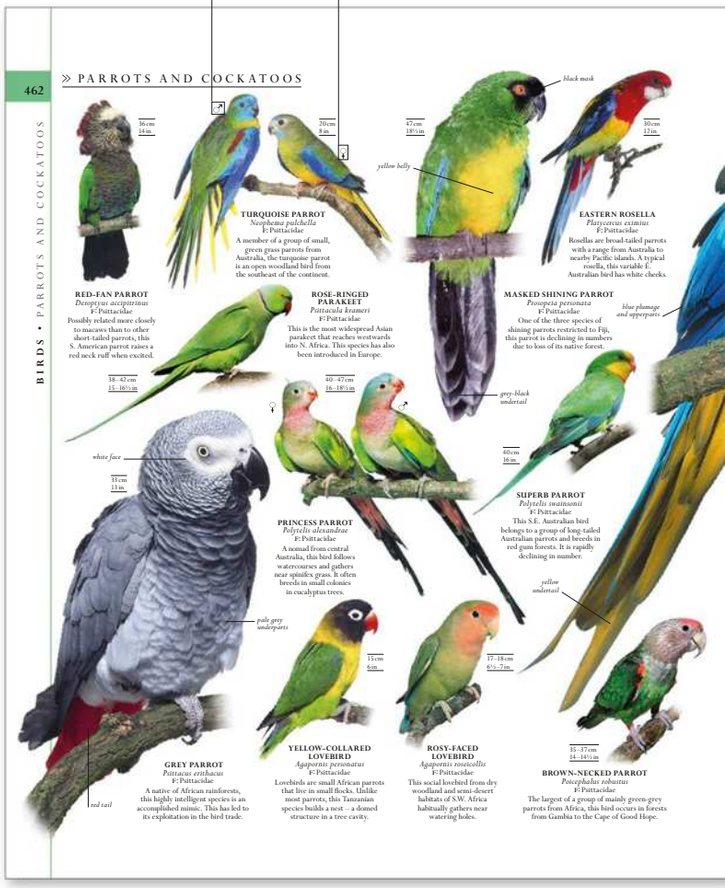
LIZARDS
REPTILES • LIZARDS
Typically, lizards have four legs and a long, thin tail, but there are also many legless species. They have scaly skin and firm jaw articulation.
CHAMELEONS
SQUAMATA: AN ALL-INCLUSIVE ORDER
CHISEL-TEETH LIZARDS
185

a male of the species ♂ *a female of the species* ♀



^ GROUP INTRODUCTION
Within each section – for example, reptiles – lower-ranking taxonomic groups, such as lizards, are explored. Key features are described, including their distribution, habitat, physical characteristics, life cycle, behaviour, and reproductive habits.

species-specific information accompanies each image

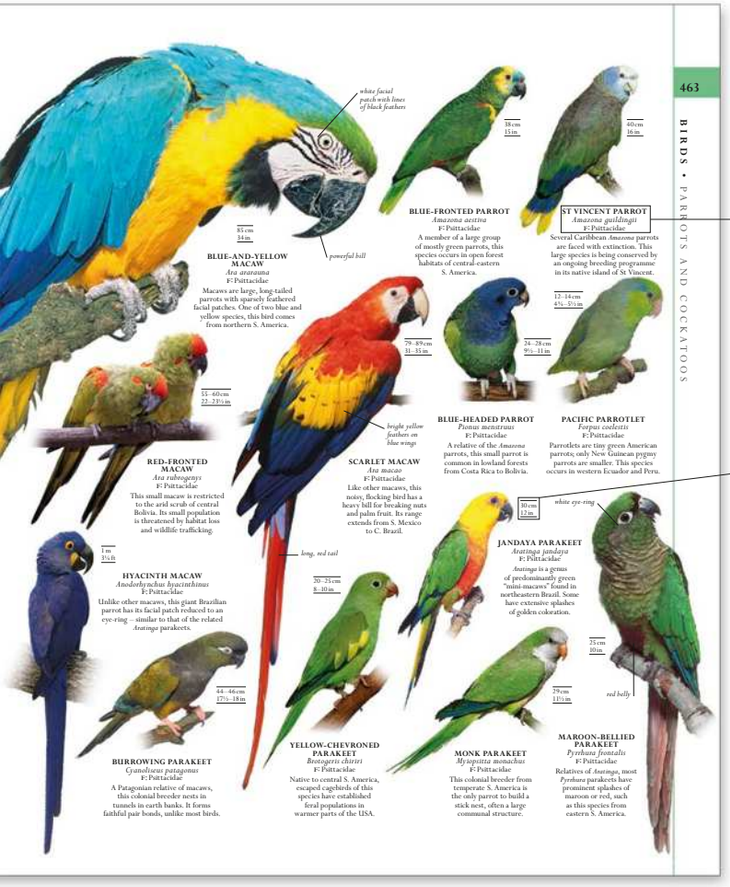
SPECIES CATALOGUE >
Pictorial galleries profile around 5,000 species, showing the distinctive visual features of each one. Closely related species are placed together for useful comparison, while essential data highlights unique and interesting aspects of each organism.

data sets display key details at a glance, such as size, habitat, distribution, and diet

SIZE 1.4–2.9 m (4½–9½ ft)
HABITAT Forests, swamps, scrub thickets, savanna, and rocky landscapes
DISTRIBUTION India to China, Siberia, the Malay peninsula, and Sumatra
DIET Mainly hoofed animals, such as deer and pigs; may also catch smaller mammals and birds

∨ FEATURE PROFILE
Zooming in on single specimens, feature profiles use close-up photographs to provide in-depth portraits of some of the world's most spectacular species.

each feature includes a side profile of the animal, plant or fungus



ST VINCENT PARROT
Amazona guildingii
F: Psittacidae

species' common names are highlighted in bold, scientific names are in italics; in some cases the family (F) name is given below

30 cm
12 in

size boxes give the most appropriate measurement for the organism they accompany (see panel, right)

DATA

MEASUREMENTS

The approximate sizes of the organisms in this book are given in data sets and size boxes. Below is a list of the dimensions used:

MICROSCOPIC LIFE
Length

PLANTS
Maximum height above ground, except for:
Height above water rushes
Spread aquatic plants

FUNGI
Width (of widest part), except for:
Height stinkhorn, dog stinkhorn

INVERTEBRATES
Adult body length, except for:
Height sponges, feather stars, common hydra, feather hydroid, pink-hearted hydroid, fire "coral" hydroid, tall anemones, tall corals
Diameter snailfur, blue button, eight-ribbed hydromedusa, cup hydromedusa, freshwater jellyfish
Diameter, excluding spines echinoderms
Diameter of medusa jellyfish
Wingspan butterflies and moths
Length of colony bryozoans
Length of shell molluscs, shelled gastropods
Spread of tentacles octopuses

FISH, AMPHIBIANS, AND REPTILES
Adult body length from head to tail

BIRDS
Adult body length from bill to tail

MAMMALS
Adult body length, excluding tail, except for:
Height to shoulder elephants, apes, even-toed ungulates, odd-toed ungulates

PLANT ICONS

The basic shape of all trees, shrubs, and woody plants is described using one of the following symbols. Herbaceous perennials which die back each winter are not given symbols.

TREES
- Broadly columnar
- Broadly conical
- Large weeping
- Small weeping
- Multi-stemmed tree
- Narrowly columnar, flame-shaped
- Narrowly columnar
- Narrowly conical
- Rounded, broadly columnar
- Rounded, broadly spreading
- Single-stemmed palm
- Multi-stemmed palm, cycad or similar

SHRUBS
- Bushy, mound-forming
- Bushy, suckering
- Compact, bushy
- Erect, tree-like
- Loose, open
- Open, spreading
- Rounded, bushy
- Spreading, prostrate
- Upright
- Upright, arching
- Upright, vigorous, bushy
- Sprawling, climbing

ABBREVIATIONS

SP.: species (used where species name is unknown)
MYA: million years ago
H: hardness of a mineral, measured on the Moh's scale
SG: specific gravity – a mineral's density is measured by comparing its weight to that of an equal volume of water

LIVING EARTH

Our blue planet, spinning in the vastness of space, is the only proven home of living things. Over nearly 4 billion years, life has evolved from the simplest of beginnings. Most species have become extinct, but life itself has flourished, endlessly diversified, and recovered from repeated extinctions. The result is an extraordinary variety of living things, which scientists continue to study as they piece together the story of life on Earth.

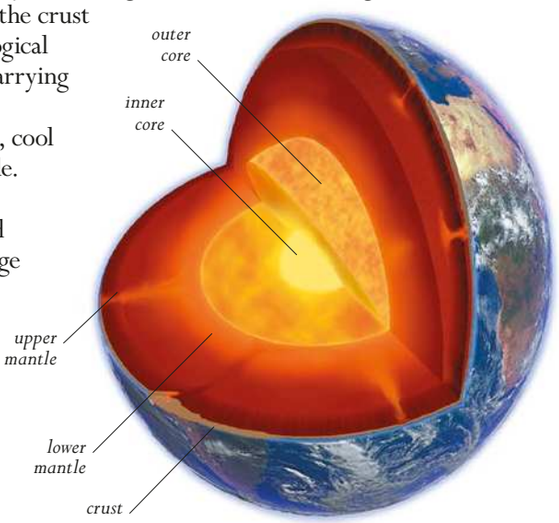
A LIVING PLANET

Earth is uniquely equipped to support a wide diversity of life, both on land and in the seas. Without heat and light from the Sun, plentiful supplies of water, the protection provided by the atmosphere, and chemicals from the rocks that form the basis of Earth's ecosystems, life would perish.

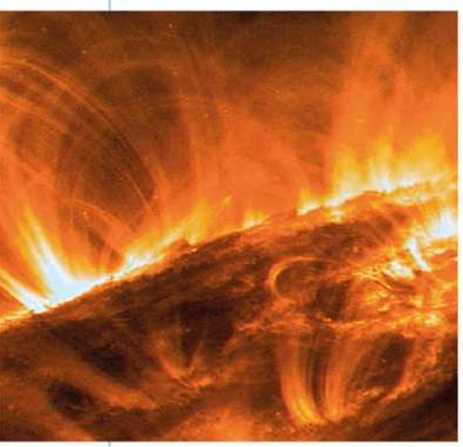
DYNAMIC EARTH

Within our Solar System, Earth seems to be uniquely placed to support abundant life. The third planet from the Sun, Earth is neither too close to nor too far from the Sun's heat. It therefore retains an outer atmosphere of oxygen and other gases, and a hydrosphere of plentiful surface water. Together, these form a protective, insulating layer that enables life to flourish. In contrast, the other planets in the Solar System are either too hot or too cold, and devoid of the levels of water and oxygen required to support detectable life.

Earth has a layered structure, with an extremely hot, solid metallic core at its centre, surrounded by an outer molten layer. This, in turn, is surrounded by a thick and hot silicate mantle, which rises to a thin, cool, and brittle outer crust. The mantle is constantly churned by heat rising from the core, which generates new ocean floor rocks and breaks the crust into large "plates". Over geological time, some oceans expand, carrying continents with them. Other oceans become smaller as old, cool crust descends into the mantle. Continents collide forming mountain ranges. Life has had to adapt to the constant change in Earth's environment.



EARTH'S STRUCTURE >
The liquid mantle is constantly stirred by heat rising from the core. This moves the plates of the outer crust, causing earthquakes and volcanic eruptions on the surface.



^ SOLAR FLARES
The Sun's energy is dramatically released from the surface in periodic explosions, which heat its atmosphere to form solar flares of hot ionized gas.

SUN AND MOON

The Sun and the Moon both have a direct impact on life on Earth. Without the Sun's energy, in the form of heat and light, there would be no life. Solar energy heats Earth's atmosphere, the oceans, and the land, producing our varied climate. Because Earth rotates at an angle while it orbits the Sun, the Sun's radiant energy is unevenly distributed over its surface. This results in daily, seasonal, and annual variations in light, heat, and living conditions for plants and animals. Even at the equator, there are marked temperature changes between day and night. The orbit of Earth's satellite moon and its gravitational pull raise tides in Earth's oceans and seas. Tidal cycles are especially influential on coastal life, which has to adapt to changing conditions.

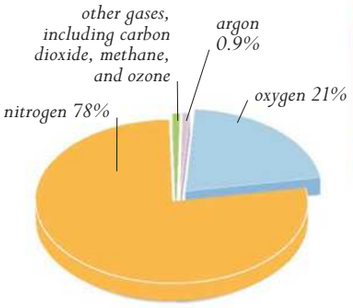
WATER AND LIFE
Life depends upon water, which forms over 50 per cent of all living tissues. Most rainfall is driven by evaporation from the oceans, which hold 97 per cent of Earth's surface water, and a vital network of rivers flow in all but the world's hottest, coldest, and driest places.

FRAGILE ATMOSPHERE

Earth's atmosphere is 120 km (75 miles) thick. It is made up of several layers, each with its own temperature and gas composition. Its density decreases with height, until it becomes the sparse, outermost layer, called the ionosphere. The ozone layer, in the lower atmosphere, plays a vital role in protecting life, because it absorbs harmful radiation such as ultraviolet light, which damages living cells. Before the ozone layer formed, life was confined to the seas, whose waters offered some protection against ultraviolet light.

The majority of water vapour and weather activity is restricted to the lowest 16 km (10 miles) of atmosphere, known as the troposphere. Earth's surface water and gaseous atmosphere interact to recycle water from the surface into the atmosphere and – through clouds, rain, and snow – redistribute it over the land and sea. From the land, water flows back into the sea, although large quantities are held back in lakes, ice, and under the ground.

ATMOSPHERIC GASES >
Nitrogen and oxygen make up over 99 per cent of Earth's atmosphere, along with small but important volumes of water vapour, carbon dioxide, and several other gases.



^ BLUE PLANET
Around two-thirds of Earth's surface is covered with water, which supports the abundance and diversity of life.

^ LAYERS OF ATMOSPHERE
Earth is surrounded by a thin, layered atmosphere, composed of water vapour and various gases, which trap solar energy and heat the surface.

VARIED ROCKS

There are around 500 different kinds of rocks on Earth, made up of varying combinations of thousands of naturally occurring minerals. All rocks have a specific composition and properties, and can be divided into three main categories: igneous rocks were originally molten; sedimentary rocks are deposited at Earth's surface; and metamorphic rocks result from the alteration of existing rocks within Earth's crust. These different types of rock are exposed on the surface by a mixture of uplift, driven by Earth's moving crust, and surface processes such as weathering and erosion. Erosion also modifies the rocks to produce multiple kinds of landforms, soils, and sediments. These are the inorganic elements on which life depends.

IGNEOUS ROCKS
The cooling and solidification of molten rock produces crystalline igneous rocks. Their composition and texture vary – rapid cooling produces fine grained rocks, and slow cooling produces coarse grained rocks.

BASALT

METAMORPHIC ROCKS
The application of heat and pressure to existing rocks deep within Earth's crust can change their form and mineral composition, resulting in metamorphic rocks such as slate, schist, and marble.

BIOTITE SCHIST

SEDIMENTARY ROCKS
Layers of sediment and the remains of plants and animals are deposited by wind and water. Over time, older and deeper buried sediments undergo compression and chemical change which transforms them into rock.

SANDSTONE

ACTIVE EARTH

Earth's surface is constantly changing, thanks to dynamic geological processes driven by its internal heat energy. The plates of Earth's brittle outer crust are always in motion, altering the shape of oceans and continents as they do so.

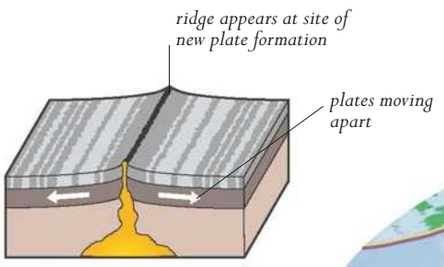
^ SAN ANDREAS FAULT
Stretching some 1,300 km (810 miles) through California, this dramatic fault is the product of a transform boundary between the Pacific and North American plates, which slide against one another.

PLATE TECTONICS

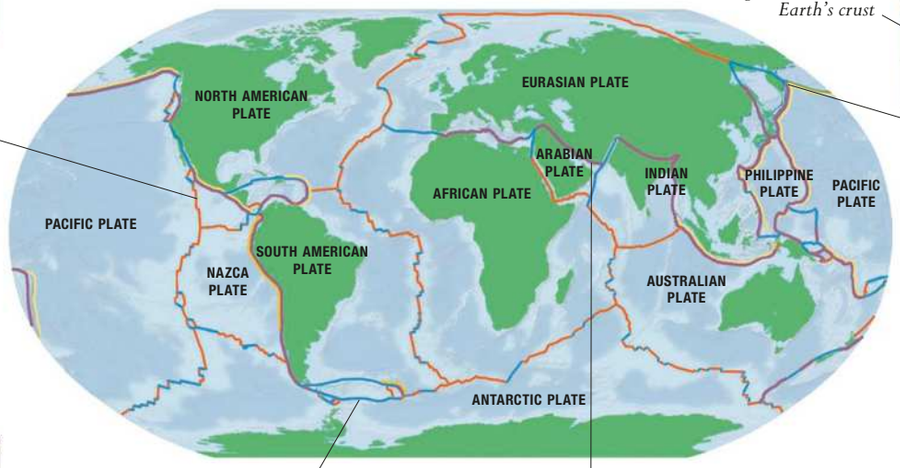
Over geological time, Earth's surface – and the distribution and size of the continents and oceans – has constantly changed, driven by the process of plate tectonics. The cool and brittle rocks of Earth's outermost crust are broken into a number of semi-rigid slabs known as tectonic plates. There are seven major continent-sized plates and about a dozen smaller ones. Over time, crustal plates have jostled against one another. Hot magma rising from the mantle erupts from rifts in the crust to form new ocean floor crust. This spreads away on either side of the rift to form divergent plate boundaries, mainly beneath the oceans. And, since Earth itself cannot expand, the creation of new oceanic crust requires that the crust is shortened elsewhere by the same amount. This reduction occurs at convergent boundaries where either one plate overrides the other – a process known as subduction – or the plate margins are compressed and buckled to form mountains.

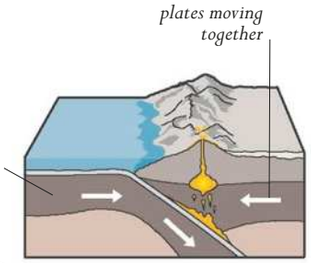
v PLATE BOUNDARIES
This map shows the main plates that form the jigsaw surface of Earth's crust. A study of earthquake locations worldwide established where the plate boundaries lie.

MAP KEY
- Convergent boundary
- Divergent boundary
- Deep-sea trench
- Transform boundary

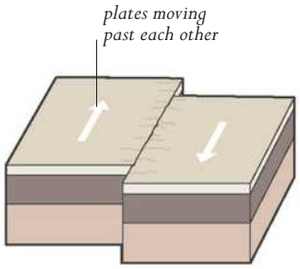


DIVERGENT BOUNDARY
As plates are pulled apart they stretch and break, forming faulted rifts and volcanically active ridges.



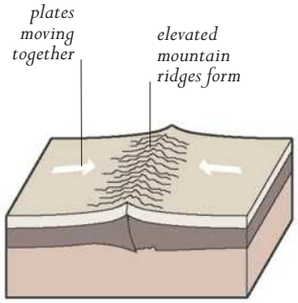


SUBDUCTION ZONE
Where two plates converge and one plate is thicker, it pushes the thinner plate beneath it in a process called subduction.



TRANSFORM BOUNDARY
Also known as conservative plate boundaries, these occur when two plates slide horizontally past one another, neither destroying or creating new crust.

CONVERGENT BOUNDARY
Where two converging plates are of similar density and thickness, their leading edges are crumpled, faulted, and thickened to form mountain ranges such as the Himalayas.



< FOLD MOUNTAINS
The intense pressure caused by converging plate margins folds, faults, and thickens the rocks of the crust. And, crustal thickening elevates mountain ranges.

ACTIVE VOLCANOES >
Most volcanoes form at plate margins. Deep down, rocks melt to produce hot magma which rises and erupts at the surface. Even dormant volcanoes may one day erupt as plates shift beneath them.

MOUNTAINS AND VOLCANOES

One of the major factors controlling the movement and distribution of life on Earth is its varied topography – its surface features – including the towering mountains and volcanoes on land and under the sea. On land, mountains not only hinder the movement of wildlife but alter weather, climate, and local plant life, which in turn impacts upon animal life. Active volcanoes also affect their surroundings when they erupt – initially by destroying life, but also, in the longer term, when the weathering and erosion of erupted lava and ash provide new mineral nutrients that fertilize the area. Submarine mountains and volcanic eruptions affect the movement of water, marine life, and the fertility of ocean waters.

WORN AWAY
Weathering by wind and water can result in the significant erosion of rocks and the sculpting of land surfaces, as seen here in the dramatic landscape of Bryce Canyon, Utah, USA.

WEATHERING AND EROSION

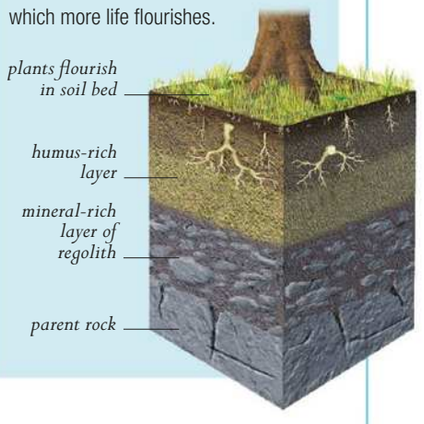
Many rocks are formed below Earth's surface, and when they are exposed by uplift from pressure within Earth's crust or by retreating seas or rivers, they react in many ways with the atmosphere, water, and living organisms. The physical and chemical processes resulting from the interaction of rocks and minerals with the atmosphere are known as weathering. The processes by which rock material is loosened, dissolved, and transported away is known as erosion. The combination of weathering and erosion wears down Earth's rocky surfaces, layer by layer. Exposed rocks on mountain tops and on the exterior of buildings, for example, are subject to chemical weathering by acid rain and to physical weathering by temperature change and the splintering freeze-thaw effect of ice formation. Bare rock surfaces may also be physically eroded by sand particles carried by the wind. The combined effect of weathering and erosion dissolves some rocks, and reduces others to fragments. As rock debris is broken down and transported by wind, water, and ice, the sediment created becomes increasingly available to life forms, providing important mineral nutrients and a new surface for anchorage and growth.

< LANDSLIDE, RIO DE JANEIRO
Even with a well-developed plant cover, the impact of high rainfall on an area of steep slopes has the potential to cause landscape-altering and even life-threatening occurrences such as avalanches and landslides.

SCIENCE

SOIL FORMATION

The production of a soil requires the initial weathering and erosion of the parent rock, which is broken down into small, mineral-bearing particles known as regolith. The addition of humus – organic matter formed from the remains of plants and animals – forms the basis for a soil. The soil in turn becomes the bed in which more life flourishes.



CHANGING CLIMATES

The features of our seasons – for example, hot, dry summers and cold, icy winters – make up the climate of each region. Earth's climate has always changed at different rates, places, and times, and this variation in conditions has considerable and continuing impact upon the evolution of life.

WHAT IS CLIMATE?

Climate is a region's average weather over a long period of time, produced by all the atmospheric conditions such as temperature, rainfall, wind strength, and pressure. The climate of any given place is also partly controlled by other factors such as human input, height above sea level, local topography, proximity to seas and oceans – with their prevailing winds and water currents – and, most importantly, its latitudinal position between the equator and pole. Latitude controls the amount of solar radiation received in different regions of the world. For instance, there is a major difference between climates of polar regions, which receive the least light and heat, and of tropical regions around the equator, which receive the most.

< CHANGING TREE LINE
As the air temperature declines with increasing altitude, plant life changes. Broadleaved trees are replaced by conifers, then shrubs.

CHANGING CONDITIONS

Global climates are generally classified according to the average temperature and the amount of rainfall each area receives, and their combined effect on plant growth. For instance, equatorial regions at present are hot and wet because oceans dominate there, whereas deserts are dry and polar regions are cold. However, this has not always been the case. Factors controlling weather conditions over geological time have affected the climate of the planet, from ice ages through to global warming.

ARCTIC FOX IN SUMMER

ARCTIC FOX IN WINTER

^ SEASONAL ADAPTATION
Annual climate change can bring acutely different living conditions from one season to the next. Animals and plants have various means of adapting to these changes; for example, the Arctic fox grows a thick coat in winter, which it sheds in summer.

LIFE IN THE DESERT
Plants such as cacti have adapted to life in semi-arid environments by slowing growth, reducing the leaves to spines (to stop water loss from transpiration), and evolving special tissues that retain water.

< EVIDENCE OF CLIMATE CHANGE
Studies of polar ice core samples have revealed details of past climate change. The chemical analysis of trapped gas bubbles helps provide an approximate measure of the temperature of the atmosphere at the time the ice was formed.

< ICE CORE SAMPLE
This is a close-up of an ice core sample recovered from Lake Bonney, Antarctica, which has a permanent ice cover. It shows trapped bubbles of air and sediment particles from the lake bed.

CLIMATE CYCLES

There is clear evidence from rocks and fossils that Earth's climate has changed significantly over time and that this has affected the evolution and distribution of life, and led to the extinction of many species. There are a number of causes of this natural climate change, including volcanic activity – which pollutes the atmosphere with ejected gas and dust – and changes in ocean currents, which move heat around the globe. Change is also driven by the orbital and rotational cycles of the planet, which affect the amount of solar radiation that reaches Earth's surface. This in turn influences the planet's temperature and climate, and triggers Earth's cycles of ice ages and greenhouse periods.

CHANGING GEOGRAPHY

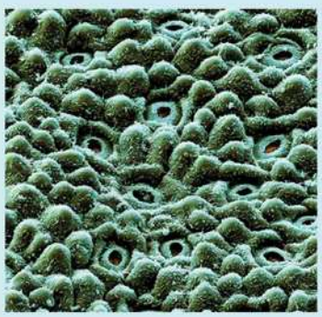
Over time, continents have been displaced as oceans have expanded and contracted due to plate tectonics. As continents moved from one hemisphere to another they passed through different climatic zones and, at times, formed supercontinents. The size of these huge landmasses affected regional climates. In addition, the changing shape of ocean basins has altered water circulation, which in turn changes the temperature and humidity of the atmosphere above, and so affects climate.

GREENHOUSE AND ICE AGES

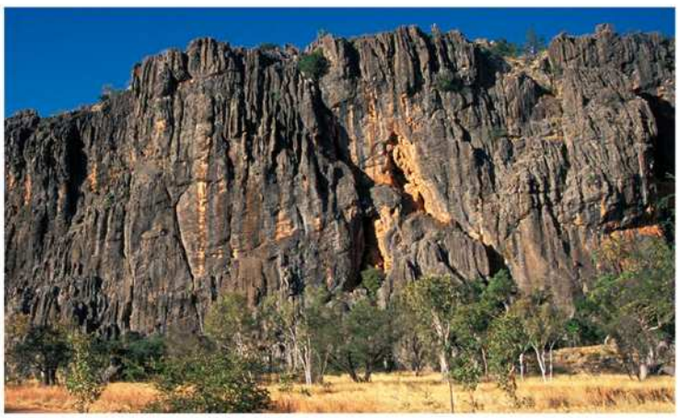
Long-term changes in climate are divided into cold periods – ice ages, when there were long-lasting ice sheets at the poles – and warmer, greenhouse periods with largely ice-free poles. Warm phases are linked to the release of greenhouse gases, such as carbon dioxide, by plants into the atmosphere. These trapped heat in Earth's atmosphere and produced huge, shallow seas, arid zones, and lush forests that, in the time of the dinosaurs, provided them with plentiful food. Ice ages, lasting millions of years, can be traced from the impact that glaciation has left on the landscape. Fossils show how rapid climate change associated with ice ages had a dramatic impact upon life on a global scale.

SCIENCE
STUDYING STOMATA

Plant growth depends upon an exchange of gases between the atmosphere and the plant tissue, through special gaps between the leaves' cells called stomata. The stomata open and close to take in carbon dioxide for photosynthesis and allow waste water and oxygen to escape. In general, plants adapt to high levels of atmospheric carbon dioxide, associated with warm "greenhouse" climates, by evolving high densities of stomata on the leaf surface. Fossil evidence of changes in the stomatal density of certain plants tracks changes in atmospheric carbon dioxide over time.

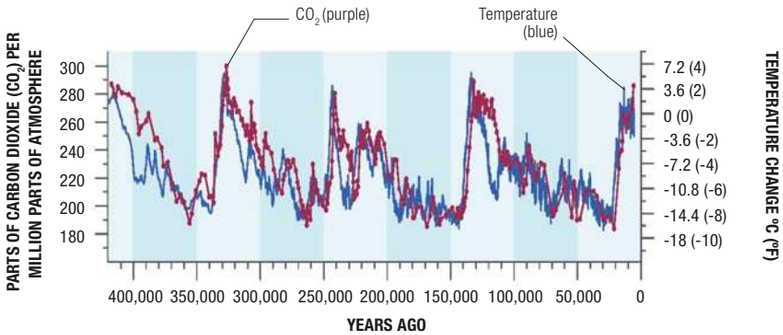


EUCALYPTUS STOMATA



^ DEVONIAN CORAL REEF
Earth's changing climate is spectacularly illustrated by this limestone outcrop in The Kimberleys, W. Australia. In the Devonian Period (400 million years ago), the area was under water and the cliff was a barrier reef.

v CARBON DIOXIDE AND TEMPERATURE
Gas bubbles trapped in polar ice cores indicate the fluctuating temperature of the planet – the higher the amount of carbon dioxide detected in the ice core, the higher the atmospheric temperature would have been at that time.

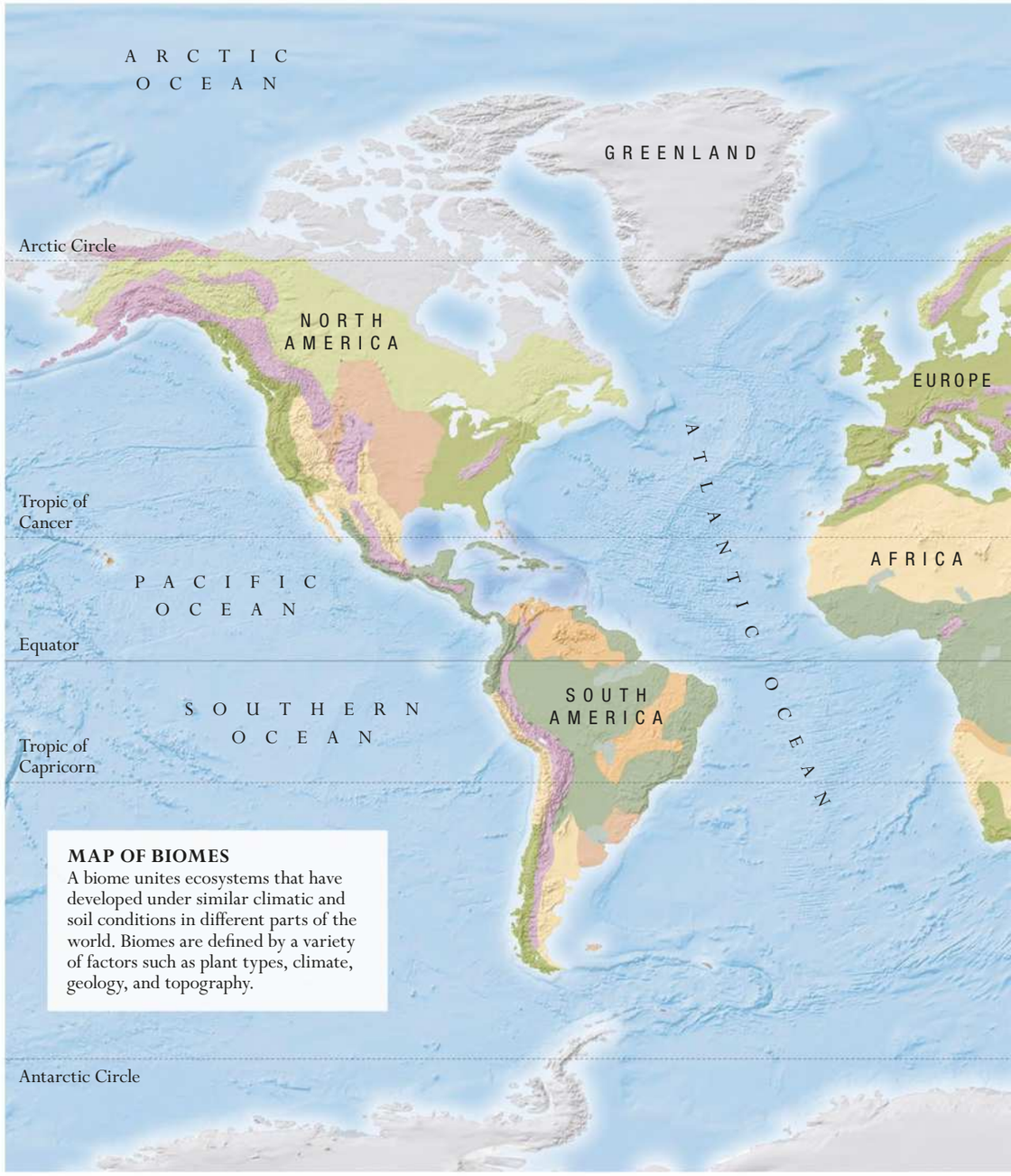


HABITATS FOR LIFE

Earth's uniquely varied habitats enable it to support an abundantly rich diversity of animal and plant life – from the extreme depths of the ocean floors to the highest mountains, and from arid deserts and grasslands to the warm, wet tropics.

Each life form has its preferred habitat – the one to which it has adapted over thousands or even millions of years. However, Earth's varied environments allow many different kinds of animals and plants to live in the same habitat – a phenomenon known as biodiversity. Over geological time, life has had to adapt to environmental change, especially rapid climate change, with both extinctions and the evolution of life forms to colonize new habitats. The presence of these pioneering organisms in turn produced changes in the environments they colonized, by forming soils for instance, and these modifications encouraged further colonization by new life forms.

Differences in habitats are produced by many factors, ranging from an area's height above sea level, its distance from the equator, and its topography (or physical shape). Some areas of the globe are biodiversity "hotspots", rich in animal and plant life – most notably tropical reefs and rainforests – while other areas with more extreme conditions support only a few, though often richly populated, species.



MAP OF BIOMES
A biome unites ecosystems that have developed under similar climatic and soil conditions in different parts of the world. Biomes are defined by a variety of factors such as plant types, climate, geology, and topography.

SCIENCE
LEVELS OF LIFE

Organisms rarely exist entirely on their own, even in the remotest places on Earth. The interactions between wildlife create different levels – from the individual organism to the overall ecosystem which it inhabits and shares with others.

INDIVIDUAL
A single, usually independent and habitat-restricted member of a population.

POPULATION
A group of individuals of the same species that occupy the same area and interbreed.

COMMUNITY
A naturally occurring collection of plant and animal populations living within the same area.

ECOSYSTEM
A biological community and its physical surroundings, which support one another.

GRASSLAND
The evolution of grass plants some 20 million years ago, and the colonization by grazing mammals, transformed Earth's landscapes. Temperate grasslands are generally treeless and have extremely fertile soils. Savanna grasslands, as shown here, are more like open woodland, featuring scatterings of trees and scrubs.

DESERT

Extreme lack of rain and soils for sustained plant growth creates deserts, which at present account for about a third of Earth's landscapes, although this proportion is increasing. The largest desert is the African Sahara.

RATTLESNAKE

POLAR REGIONS

The Arctic and Antarctic experience extreme seasons, with 24-hour daylight in summer and perpetual darkness in winter. Dominated by snow and ice, and with vast, dry areas of polar desert, both are highly vulnerable to climate change.

ROCKHOPPER PENGUIN

TROPICAL FOREST

The richest wildlife habitats on land are found in the forests of the tropics – Earth's hottest areas, which lie by the equator. Their numerous ecosystems are important yet increasingly vulnerable biodiversity hotspots.

STRAWBERRY POISON-DART FROG

TEMPERATE FOREST

Temperate environments lie between the tropics and the polar regions. The influence of both tropical and polar air masses promotes vast forests with considerable biodiversity. However, clearing by humans has greatly reduced their extent.

RED DEER

CONIFEROUS FOREST

Coniferous forest trees, such as redwoods, spruce, and fir, belong to an ancient plant group and are the world's toughest trees. Evergreen with small leaves, they thrive where few other trees can, in cold areas and in mountain ranges.

BROWN BEAR

MOUNTAINS

Reaching as high as 9 km (5½ miles) above sea level, Earth's mountains are home to many different environments. A single mountain can rise from temperate woodland up to arctic conditions as the climate changes with altitude.

PEREGRINE FALCON

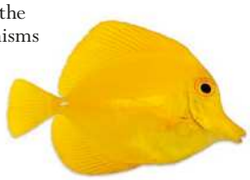
RIVERS AND WETLAND

A wide range of animal and plant life thrives in Earth's rivers and lakes. Landscapes saturated with water, either permanently or seasonally, form distinctive wetlands, where areas of open water mix with dense vegetation.

DRAGONFLY

CORAL REEF

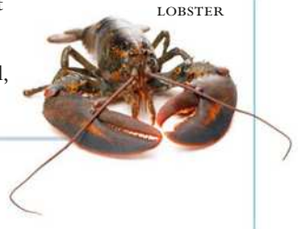
Coral reefs develop from the skeletons of marine organisms in shallow, sunlit tropical waters. Supporting an immense variety of life, they are the rainforests of the aquatic world.



YELLOW TANG FISH

OCEANS

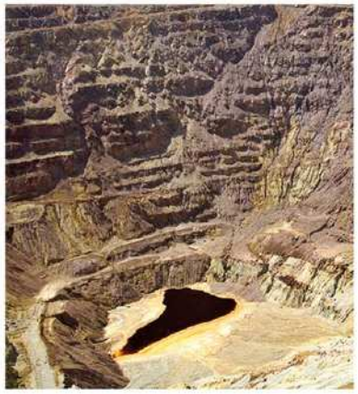
Life in oceans is found at all levels, from the sunlit surface to the deepest depths. Covering two-thirds of the planet, oceans form the largest continuous habitat on Earth and support very varied life forms – from microscopic plankton to the largest living mammal, the blue whale.



LOBSTER

HUMAN IMPACT

The rapid growth of the human population has had an enormous impact upon Earth's natural environments, affecting the climate and countless species of plant and animal life. Some of these changes are irreversible.



^ **SCARRED LANDSCAPE**
The growth of industry has required the exploitation of raw materials. Their extraction, such as at this copper mine, has changed global landscapes for ever.

^ **ATMOSPHERIC POLLUTION**
Slash-and-burn forest clearing for agriculture not only releases atmospheric pollutants but also diminishes the capture of carbon dioxide by the plant life.

ENVIRONMENTAL CHANGE

Earth has a long history of climate change with dominant warm "greenhouse" climates, widespread forestation, and no polar ice punctuated by glacial "ice ages". Global warming is known to be linked to high levels of greenhouse gases in the atmosphere, such as carbon dioxide and methane, which trap incoming solar energy and raise the temperature of the oceans, land, and air. In the past, natural increases in atmospheric carbon dioxide have been balanced by the development of forests on land and lime-rich sediments in the seas, which eventually became coal and limestone and stored excess carbon dioxide effectively. Since the industrial revolution of the 19th century, human activity has released huge amounts of carbon dioxide and other greenhouse gases back into the atmosphere through the mining and burning of fossil fuels, the clearing of forests, and the rearing of cattle.

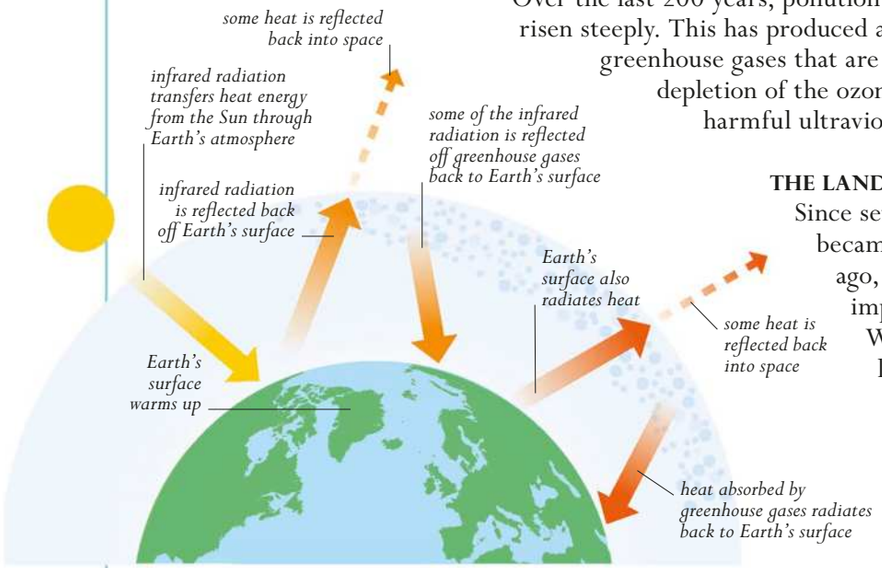
THE OCEANS

The health of Earth's oceans is vital to all life. Marine life depends upon the circulation of oceanic waters that contain enough oxygen and nutrients to support the food chain from plankton and shellfish to all the other animals that depend upon them for food. Fossil records show that when the oceanic environment deteriorated in the past, it led to extinctions of life. Today, over-fishing and pollution, especially with plastics, by humans are affecting the marine environment.

THE ATMOSPHERE

For thousands of years human activity has affected the atmosphere. Initially, it was restricted to the release of pollutants from domestic fires and forest clearance. In Roman times metal production released the first industrial pollutants into the atmosphere, leaving traces that can be seen in polar ice cores. Over the last 200 years, pollution by gases and particulates has risen steeply. This has produced acid rain and smog, and greenhouse gases that are linked to global warming and depletion of the ozone layer, which helps screen out harmful ultraviolet radiation.

v **GREENHOUSE EFFECT**
An excess of greenhouse gases in the atmosphere creates a shield which prevents some of the Sun's energy from radiating back into space


some heat is reflected back into space
infrared radiation transfers heat energy from the Sun through Earth's atmosphere
some of the infrared radiation is reflected off greenhouse gases back to Earth's surface
infrared radiation is reflected back off Earth's surface
Earth's surface also radiates heat
some heat is reflected back into space
Earth's surface warms up
heat absorbed by greenhouse gases radiates back to Earth's surface

THE LAND

Since settlements and agriculture became widespread 8,000 years ago, humans have had a growing impact upon Earth's landscapes. Worldwide population growth, land settlement, and demand for food has left few untouched landscapes. Greater awareness of the impact of human activity on the environment is now leading to efforts to conserve natural habitats.

v **POLAR ICE SHELF COLLAPSE**
Rising temperatures are leading to the collapse of the polar ice shelves. The release of such large volumes of water is raising sea levels, which in turn threatens coastlines.

AGRICULTURE
Natural landscapes are radically altered by intensive farming, such as the cultivation of rice in irrigated terraces throughout Asia. Such methods support big populations, but require large amounts of water.

EXTINCTION

The inability of many organisms to adapt to environmental change has led to a huge turnover of species throughout geological time. In fact, the vast majority of nature's species are now extinct. Only the fittest organisms survive, usually through gradual adaptation, but sometimes by the sudden elimination of competitors. For example, when a huge asteroid hit Earth 66 million years ago, it set in motion a chain of events that led to the demise of many life forms, including the dinosaurs on land and the ammonites in the seas. But it also opened the way for the rapid evolution of mammals including humans. More recently, the arrival of modern humans in different regions around the world has contributed to the extinction of particular species, such as the woolly mammoth in Europe and Asia (see far right). Today, as the human population expands, our actions are placing a growing number of species, such as the tiger, in imminent danger of extinction.

^ DECLINE OF THE CRESTED IBIS
Once widespread in Asia, hunting and habitat loss has restricted the crested ibis to a small wild population in China. Captive breeding has allowed it to be reintroduced to Japan.

< PERE DAVID'S DEER
Extinct in the wild, this east Asian deer has survived only in captive herds bred in England since 1900. Père David's deer reintroduced to China in the 1980s now form a population some 700 strong.

SCIENCE
MAMMOTHS NO MORE

Woolly mammoths were elephants that were adapted to the cold. They migrated across ice-age Europe and Asia in vast herds. Archaeological evidence such as cave paintings shows that they were actively hunted by humans around 30,000 years ago, which may have contributed to the extinction of most woolly mammoths by 11,000 years ago.

CAVE PAINTING, PECH-MERLE, FRANCE

ORIGINS OF LIFE

The fossil record shows that life first appeared on Earth at least 3.7 billion years ago, and that all complex life has evolved from these first simple forms. Today, diverse life forms range from single-celled organisms to mammals with a complex anatomy.

WHAT IS LIFE?

Several features distinguish living organisms from inanimate, inorganic matter, although the existence of viruses blurs the boundary between the living and non-living. These features include an ability to take in and expend energy, to grow and change, to reproduce, to adapt to its environment, and – in more complex living organisms – to communicate.

The cell is the fundamental unit of life, capable of replicating itself and carrying out all living processes. Even the smallest independent organisms are made up of at least one cell, and almost every cell of every living organism has its own set of molecular instructions. Within each cell, the thread-like chromosomes carry hereditary information in the form of genes, which are responsible for the particular characteristics of an organism. The set of instructions in a gene are mainly recorded in the form of a molecule called chromosomal deoxyribonucleic acid (DNA). The DNA of an organism carries information from one generation to another, allowing certain characteristics to be passed on from parent to offspring.

^ **VITAL ENERGY**
To sustain itself, life must obtain energy from the environment. Energy flows mostly from photosynthesis in plants – but also occasionally from chemosynthesis in bacteria – to the animals that feed upon them and are, in turn, eaten by other animals.

^ **PHOTOSYNTHESIS**
Plants use the pigment chlorophyll to capture light energy and convert water and carbon dioxide into sugars and oxygen. This benefits other life forms that feed on the plants and breathe in oxygen.

DIVISIONS OF LIFE

The huge array of life on Earth is divided into three domains or superkingdoms – Archaea, Bacteria, and Eukaryota – which encompass all life forms from plants and fungi to animals. Archaea and bacteria are primitive, single-celled organisms, and were probably the earliest form of life on Earth. The more advanced eukaryotes are distinguished from archaea and bacteria by having a cell nucleus, which contains the cell's genetic material, DNA. Eukaryotes vary enormously in shape and size, ranging from single-celled organisms to complex, multi-celled plants and animals.

< **GROWTH**
A capacity to grow and repair is a one of the key defining features of life. All organisms, from simple fungi to mammals, grow mostly by cell division but also increase in cell size.

SCIENCE
VIRUSES

Viruses are the most abundant biological entity on Earth, and they lie at the boundary between living and non-living. While they have features in common with living organisms – they are made of genetic material and are protected by a protein coat – viruses are parasitic and can only reproduce within the living cells of other organisms. They are tiny packets of chemicals that copy themselves, without truly being alive.

SARS-COV-2 VIRUS, THE CAUSE OF COVID-19

EARLY LIFE

The very earliest forms of life evolved in the seas, and evidence of this comes from two main sources: living primitive organisms and the fossil record. The most primitive life forms today are archaea and bacteria, which can survive even in extreme temperatures and acidic conditions. Such micro-organisms may be similar to those that first evolved in the extreme environments of early Earth.

Fossil evidence for early life is contentious. Chemical evidence of carbon derived from living organisms has been found in rocks from Western Greenland and dates back some 3.7 billion years ago. The most convincing of ancient records of life are layered, mound-shaped stromatolites (see right).

FLOURISHING LIFE
Ever since life first appeared on Earth, it has thrived in the sea, evolving into the biodiversity hotspots of modern, sunlit reefs, second only to rainforests for the variety and density of life they sustain.

< STROMATOLITES
For billions of years these layered structures have built up in shallow tropical seas by alternating layers of sediment and sheets of micro-organisms, including cyanobacteria (blue-green algae).

From the first appearance of simple life, it took at least 2.7 billion years before complex life forms appeared. The fossil of a microscopic and multi-celled red algae called *Bangiomorpha* provides the first evidence of the existence of specialized cells. These cells evolved for sexual reproduction, and also for the development of a holdfast to attach the algae to the sea floor.

Around 650 million years ago, fossils of various frond- and disc-shaped, soft-bodied, and mostly sessile organisms appeared. These marine animals were known as the Ediacaran Fauna. By the beginning of the Cambrian Period, 545 million years ago, numerous multi-celled marine organisms had evolved, including burrowing worms and a variety of small, shelled molluscs, whose bodies had muscle tissues and organs such as gills for respiration. Around 510 million years ago, the first vertebrates appeared, with an internal skeletal support for the body. By late Devonian times, around 380 million years ago, vertebrates had begun to emerge from the seas onto land.

^ BURGESS SHALE
The fossils of the Burgess Shale in Canada show that marine life diversified rapidly in Cambrian times, from sponges and arthropods to vertebrates.

WIWAXIA >
Found at the Burgess Shale, *Wiwaxia* was a 5 cm (2 in) long, mollusc-like seabed crawler with spines and scales, and a soft undersurface.

EVOLUTION AND DIVERSITY

Until the 19th century, when a number of theories were proposed, it was a matter of speculation as to how such remarkably diverse life forms had developed on Earth. Today, the theory of evolution and diversification, alongside geological evidence for changes in the distribution of continents, give a fascinating insight into the ever-changing life on our planet.

CHANGE OVER TIME

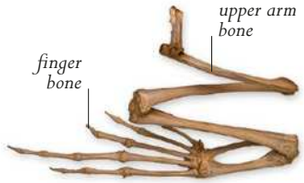
All living things can change and adapt to their surroundings. Changes that are passed from generation to generation are hard to see, but over time they can alter the way a species looks or behaves. This process, known as evolution, is not gradual but has seen significant extinctions and bursts of growth over time.

The study of fossils to unravel the history of life was in its early stages in Charles Darwin's day, and since then a vast amount of information supporting the theory of evolution has emerged. We now know that life evolved in the oceans at least 3.7 billion years ago, and that it was from these early simple life forms that all current life on Earth evolved – including plants, fungi, and animals.

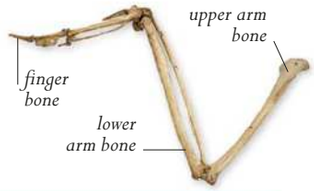
As life forms became more complex and moved from sea to land, the first forests and land-living animals evolved. The Mesozoic Era, which began 252 million years ago, with its successions of evolving plants and animals, produced the dominant dinosaur reptiles and their bird descendants. A mass extinction event 66 million years ago ushered in the Cenozoic Era. The reptiles were largely replaced by mammals both in the seas and on land, where flowering plants and their pollinating insects also became abundant and diverse.

EVIDENCE OF EVOLUTION
Comparison of the anatomy of vertebrate limb bones from different species show that, despite different appearances and functions, they derive from the same basic developmental plan and the same genes.

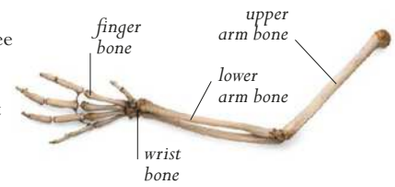
FROG
The frog's leg, arm, and finger bones are modified for swimming. Large muscles enable it to jump powerfully – essential for catching prey and escaping from predators.



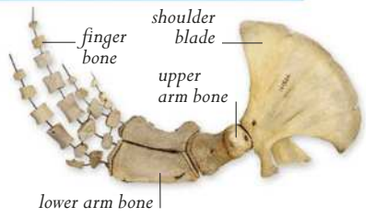
OWL
The wing of a bird is powered by flight muscles attached to the upper arm and bones of the wrist, with greatly modified and extended fingers.



CHIMPANZEE
The arm of a chimpanzee is anatomically very similar to our own, but has slightly different proportions, with elongated fingers and a short thumb.



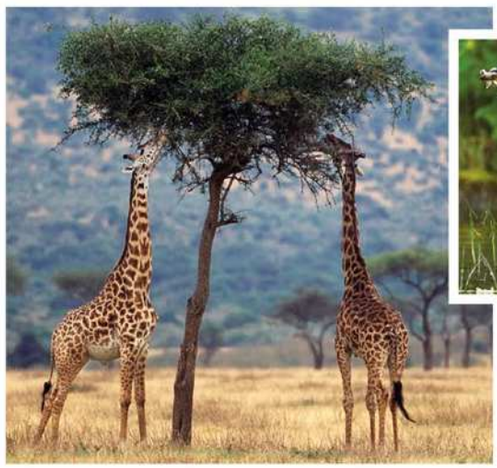
DOLPHIN
The arm bones of whales and dolphins form a flipper – with shortened, flattened, and strengthened arm bones and greatly lengthened second and third fingers.



< GIANT SALAMANDER
This extremely rare fossil skeleton of an *Andrias* (giant salamander) was mistaken for a human victim of the biblical Flood until French anatomist Georges Cuvier identified it as an amphibian in 1812.

LAMARCK LEADS THE WAY

The 18th-century French biologist Jean-Baptiste Lamarck developed the first comprehensive evolutionary theory that higher forms of life had "evolved" from simpler organisms. Based on his extensive research of invertebrates in particular, Lamarck argued that necessary characteristics could be acquired during an organism's lifetime – through the desire to gain food, shelter, and mates – and those not needed could be lost, with the resulting transformation passed on to its offspring. Although modern genetics disproves this theory of "soft inheritance", Lamarck's concepts were an important starting point, and were developed further by the Scottish anatomist Robert Grant, who tutored Charles Darwin in Edinburgh. Darwin himself did not entirely rule out a Lamarckian mechanism, which he thought might be supplementary to natural selection.



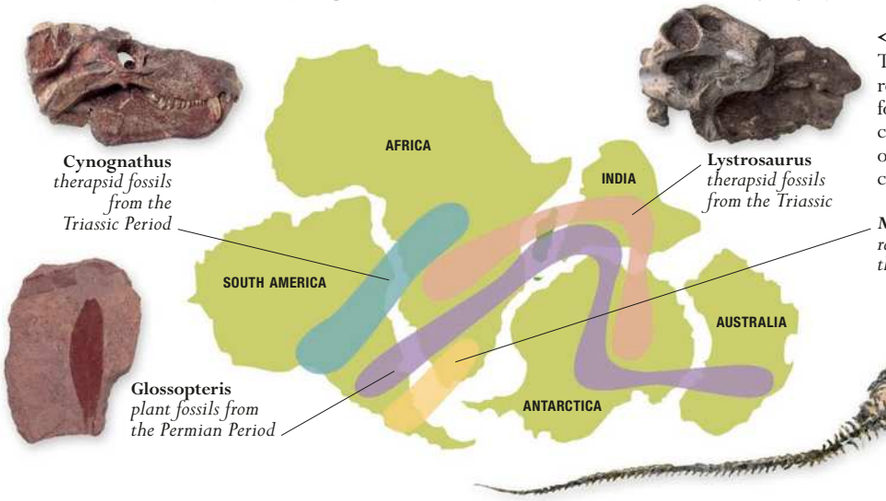
< ^ INNER STRIVING
Lamarck believed that evolution worked through a process of "inner striving". Thus the giraffe developed a long neck to reach the leaves of trees, and the heron grew long legs in order to wade.

^ GALAPAGOS FINCHES
On his voyages, Darwin collected many different specimens of Galapagos finches which he believed may have descended from a common ancestor.

DARWIN AND WALLACE

In the mid 19th century, British naturalists Charles Darwin and Alfred Russel Wallace independently came up with the theory of evolution by natural selection. They both had experience of fieldwork in the tropics – an environment boasting high biodiversity, competition for resources, and marked differences in the organisms living in separate areas. They both wondered how and why such natural phenomena had arisen. On his travels Wallace collected specimens for study and sale, and it was in the Malay Archipelago that he formulated his explanations for the geographical distribution of organisms – biogeography – and realized the role of natural selection in evolution. Meanwhile, Darwin's five-year voyage on *HMS Beagle* around the southern hemisphere as a gentleman naturalist provided him with much material to formulate his own theory of evolution. In 1858, Wallace and Darwin produced a joint publication on natural selection, and the following year Darwin expanded the theory to produce his famous and influential book, *On the Origin of Species*.

^ COLLECTION BOX
Both Darwin and Wallace were fascinated by insect diversity, especially as found in the tropics, and were keen collectors.



< BIOGEOGRAPHY
The distribution of certain reptile, therapsid, and plant fossils across the southern continents shows that they were once joined as a supercontinent, called Gondwana.

^ EARLY BIRD
The discovery of the fossil *Archaeopteryx* in 1861 revealed characteristics that provided an evolutionary link between two major groups: reptiles and birds.

EVOLUTION IN PROGRESS

Darwin and Wallace proposed the theory of natural selection, but it was the discovery of the gene that gave scientists the mechanism by which selection takes place. Understanding the gene has since become the key to understanding evolution.

NATURAL SELECTION

A key evolutionary mechanism, natural selection favours the survival of the fittest. In other words, individuals that possess characteristics best adapted to their current environment have a better chance of surviving to reproduce and pass on those favourable traits to another generation. Natural genetic variation within populations produces differences such as size, shape, and colour, and some of these may help promote survival. For instance, a particular body coloration may provide a camouflage that better hides the animal from predators than other colours would. If this leads to the survival of that animal and to its reproduction, that same improved coloration will be passed on to some of its offspring. As an environment changes over time, a different coloration might be more beneficial, and so natural selection will ensure another change. A split into two populations may be imposed by a physical barrier, with each new population becoming adapted to slightly different conditions. Eventually, this may lead to one species becoming two, in a process known as speciation.

^ INDIVIDUAL VARIATION
Litters of domestic cats commonly include individuals with varied coloration, especially where the parents' colours differ.

< v SEXUAL DIMORPHISM
There are often marked differences between males and females of the same species. Male frigatebirds have inflatable throat pouches for attracting the females.

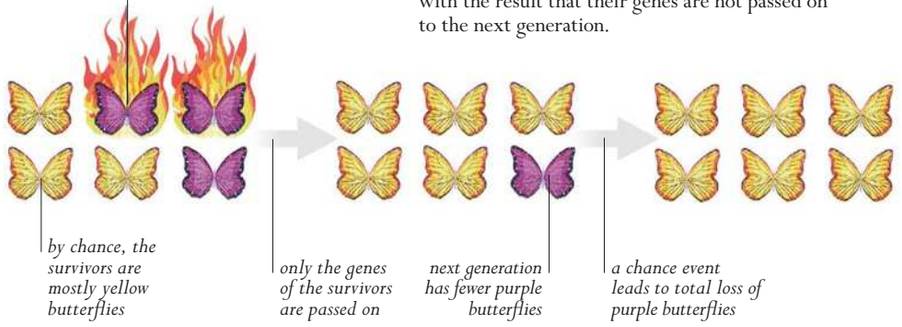
SCIENCE

CREATIONISM: BELIEF VERSUS SCIENCE

Most of the world's religions provide a theory of creation, which gives an explanation for the formation of Earth and life. Many of these creation stories originated long before scientific data and theories were available to offer alternative explanations and understanding. Some believers in the Western Judeo-Christian tradition maintain that the complexity of "design" in many organisms implies that there must have been a "designer" – God – behind their creation, and for this reason they dispute the theory of evolution.

GENES AND INHERITANCE

Particular traits pass from parents to offspring through the transmission of genetic material. Genes preserve, encoded in their DNA, all the information necessary for the replication of a cell's structure and its maintenance. Genes are therefore the basic units of heredity. Individual chromosomes – the thread-like part of a cell – hold thousands of genes on long strands of DNA. During sexual reproduction, the fusion of sperm and egg cells produces two complete sets of gene-bearing chromosomes: one copy from the father and one from the mother.


a forest fire wipes out large populations of butterflies
by chance, the survivors are mostly yellow butterflies
only the genes of the survivors are passed on
next generation has fewer purple butterflies
a chance event leads to total loss of purple butterflies

v GENES AND CHANCE
Sometimes individuals are eliminated at random, with the result that their genes are not passed on to the next generation.

ADAPTING TO EXTREMES
The lesser flamingo has evolved to occupy a very specialized niche: to feed on algae in extremely alkaline African lakes. In the absence of competitors, it can thrive there in huge numbers.

ISLAND EVOLUTION

Isolated islands provide natural laboratories for unusually fast evolution, with intense competition for limited resources leading to rapid speciation. In 1835, Darwin's visit to the Galapagos Islands allowed him to collect many bird specimens, particularly finches. He noted slight variations between the specimens from island to island. He also heard about the differences between the giant tortoises on separate islands, and subsequent visits to other Pacific islands made him wonder about the possibility of new species evolving from a common ancestor. The ornithologist John Gould was able to identify Darwin's finches as a new group of 12 separate species, rather than just varieties of the same species. This persuaded Darwin that species could change under certain conditions such as island isolation. Island wildlife continues to be an important research area for modern evolutionary biologists.

< FLIGHTLESS BIRDS
Many species of flightless birds, such as kiwis, evolved on the islands of New Zealand, which lacked serious predators until humans arrived.

ARTIFICIAL SELECTION

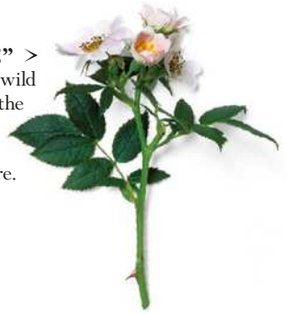
Over millennia, humans have domesticated many different kinds of animals and plants, from dogs and cattle to fruit trees and cereal crops. Before the discovery of the gene, this was achieved simply by selectively interbreeding organisms bearing the desired characteristics – such as the ability to run fast or produce more succulent fruits – over many generations, until the selected traits became dominant. Today, biotechnology achieves the same result much faster by directly manipulating genes, both to enhance beneficial traits and to remove problematic ones.

^ GENETIC MODIFICATION
Alteration to the genetic makeup of organisms can remove undesired characteristics and add more useful ones, such as resistance to disease.

^ CLONING
Genetically identical individuals can be created by the transfer of a nucleus – with its genetic information – from an adult cell into a host egg cell.

CLASSIFICATION

Global diversity is estimated to range from 10 million species to billions. Nearly 2 million have been described, with many more added each year. All species are named and classified using a system devised over 250 years ago.



"DOG ROSE" >
Known variously as the dog rose, wild briar, witches' briar, dogberry, and the hip tree, this plant has only one Latin name, *Rosa canina*, which identifies it for everyone everywhere.

< "PUMA"
The puma is also known as the cougar or mountain lion. Its Latin name, *Puma concolor*, alludes to its uniform colour.

For centuries people have studied the natural world. Initially they were limited to what they could find locally and to reports from travellers, as it was impossible to preserve and send specimens any distance. Later, as travel became easier, explorers were paid to collect plants and animals and ship's artists would draw them. By the early 1600s, natural history collections in Europe were substantial, and many specimens had been described, but there was no formal arrangement that made these specimens or accounts of them easily accessible.

The aim of the early taxonomists, or scientists who describe and classify species, was simple – to organize living things so that they reflected God's plan of creation. Between 1660 and 1713, John Ray published works on plants, insects, birds, fish, and mammals, forming his groups on the basis of morphological (structural) similarities.

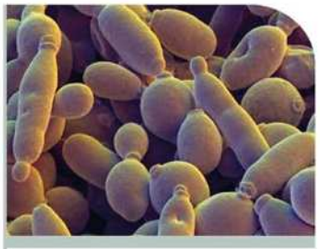
The science of morphology, along with other criteria such as behaviour and modern genetics, forms the basis of classification today. In 1758, the tenth edition of *Systema Naturae* was published. It was written by the Swedish botanist Carolus Linnaeus. He and his friend Peter Artedi had decided to divide the natural world between them and classify everything in it, fitting the 7,300 described species into the same hierarchical framework. Although Artedi died before his book was finished, Linnaeus completed the work and published it along with his own.

LATIN NAMES

All living things now have a unique Latin name – such as *Panthera leo* for the lion – which is made up of the genus name, starting with a capital letter, and a descriptive species name. Linnaeus devised this binomial method for identifying different organisms to replace the arbitrary descriptions that existed previously. The new method put an end to confusion caused by the same name being given to several species, or to single species being know by several names.

Within a species, distinct subspecies can sometimes be recognized in different locations. In the 1800s, Elliot Coues and Walter Rothschild adopted a trinomial Latin system to accommodate them. This convention for naming species and subspecies is still used today.

TRADITIONAL CLASSIFICATION



DOMAIN
Eukaryota
The latest taxonomic unit to be created is the domain. It is based on whether organisms possess cells with a nucleus (Eukaryota: protoctists, plants, fungi, and animals) or not (Archaea and Bacteria).

KINGDOM
Animalia
In recent years, the traditional kingdoms of plants and animals have been further subdivided. Kingdom Animalia now includes only multicellular organisms that must eat other species in order to survive.

PHYLUM
Chordata
A phylum (known as a division in plants) is a major subdivision of a kingdom and is made up of one or more classes that share certain features. Members of the phylum Chordata have a notochord – the precursor of the backbone.

CLASS
Mammalia
Introduced by Carl Linnaeus, a class contains one or more orders. Class Mammalia includes only animals that are warm-blooded, have fur, a single jaw bone, and that suckle their young on milk.

> CONTRIBUTING TO CLASSIFICATION
Over the years many scientists have attempted to organize the natural world, combining earlier ideas with new research, culminating in the traditional system of classification shown above and the use of bi- and trinomial Latin names. Some scientists were particularly influential, making significant contributions to taxonomy.

ANIMALS AND PLANTS

Aristotle was the first person to classify living things, and he introduced the term *genos* (meaning race, stock, kin) – genus in Latin. He separated animals into those with blood and those without, not realizing blood need not be red. This division is very close to the modern classification of vertebrates and invertebrates.

ARISTOTLE, 384–322 BCE

ORDER FROM CHAOS

John Ray classified organisms based on their overall morphology rather than just a part of it. In doing so he could establish relationships between species more easily and organize them into groups more effectively. He also divided the flowering plants into two major groups of orders – monocotyledons and dicotyledons.

JOHN RAY, 1627–1705

CLASSIFYING INSECTS
About 20,000 species of butterfly have now been described. In order to identify them or recognize new species, museums hold vast reference collections, like this one, for comparative purposes.

ORDER
Carnivora
Orders are the next level down in Linnaeus's hierarchy, and contain one or more families. The Carnivora have modified cheek teeth (carnassials) and large canine teeth specialized for biting and shearing.

FAMILY
Canidae
A subdivision of an order, a family is made up of genera and the species within them. The family Canidae has 35 living species, all with non-retractile claws and two fused wrist bones. All but one species have long, bushy tails.

GENUS
Vulpes
A term first used by Aristotle in Ancient Greece, a genus identifies subdivisions of a family. *Vulpes* is a genus within the family Canidae. All foxes have upright, triangular ears and a long, narrow, pointed snout.

SPECIES
Vulpes vulpes
The basic unit of taxonomy, species are populations of similar animals that breed only with one another. *Vulpes vulpes*, known for its bright red fur, breeds only with other red foxes.

ANIMAL, VEGETABLE, OR MINERAL

Linnaeus divided the natural world into three kingdoms – animals, plants, and minerals. He then devised a hierarchical system of classification based on class, order, family, genus, and species, and established the convention of giving species binomial Latin names.

CARL LINNAEUS, 1707–1778

A NEW KINGDOM

Historically organisms were classed as being either animals or plants, but in 1866 Ernst Haeckel argued that microscopic organisms formed a separate group, which he called Protista (now Protoctista). There were now three kingdoms of life – Animalia, Plantae, and Protista.

ERNST HAECKEL, 1834–1919

INTRODUCING THE ARCHAEA

Recognized by Carl Woese and George Fox in 1977, the Archaea are microscopic organisms that live in very extreme environments. Initially grouped with the Bacteria, their DNA turned out to be so unique that a new three-domain taxonomic system was introduced.

CARL WOESE, BORN 1928

ANIMAL GENEALOGY

In the 1950s, a revolutionary new way of classifying organisms was proposed. Called phylogenetics, it allowed taxonomists to investigate evolutionary relationships between species by placing them in hierarchical groups called clades.

Phylogenetics, also known as cladistics, is based on the work of entomologist Willi Hennig (1913–1976). He assumed that organisms with the same morphological characters must be more closely related to each other than to those that lacked them. Therefore, these organisms must also share the same evolutionary history and have a more recent ancestor in common. Like the traditional taxonomy of Linnaeus, this method of classifying organisms is hierarchical, but due to the volume of data involved, computers are used to generate the family trees, known as cladograms.

For a morphological feature to be useful in cladistic analysis, it must have altered in some way from the so-called "primitive" ancestral condition to a "derived" one. For example, the legs and paws of most carnivores are considered primitive in the cladogram on the opposite page, compared to the derived condition of flippers in the seals, fur seals and sea lions, and walruses. This derived character, called a synapomorphy, is useful because it is shared between at least two taxonomic groups, suggesting they are more closely related to each other than to groups without flippers. Characters that are unique to one group are useful for recognition purposes but say nothing about relationships. So cladistic analysis is based entirely on the identification of synapomorphic characters.

UNDERSTANDING ANCESTRY

The more derived characters organisms have in common, the closer their relationship is assumed to be. For instance, brothers and sisters look more alike than other children – they may have the same eyes, the same chin, and so on. This is because in terms of common ancestry they have the same parents but are only distantly related to other people.

Cladistics is now most commonly based on genetics – except in the study of fossils – and has exposed some unexpected shared ancestry. For example, a genetic cladogram surprisingly revealed that the whale's closest living relative is the land-dwelling hippopotamus – a relationship that Linnaeus would certainly not have expected.

SCIENCE

OUTGROUPS

The first step in doing cladistic analysis of a group is to choose a closely related but more primitive species (the outgroup) for comparison. This allows derived characters to be distinguished from primitive ones. For example, to work out a phylogenetic tree of birds, a crocodile might be chosen as the outgroup, as both birds and crocodiles belong to the clade Archosauria.

A PRIMITIVE BIRD RELATIVE

∨ CLOSE RELATIONS
The giraffes and kudus are both even-toed ungulates, so are more closely related to each other than to the odd-toed zebras. As fur-bearing mammals, all three are more closely related to each other than to the feathered birds around them.

LOOKING AT CLADOGRAMS

To do a cladistic analysis, the different groups of organisms are scored on a set of characters that are either primitive or derived. Their distribution is not always as straightforward as is shown in the diagrams below. Often the resulting cladogram can be constructed in a number of different ways and taxonomists have to choose between them. To do this they adopt the principle of parsimony – they choose the cladogram involving the least number of steps or character transformations to explain the observed relationships between the groups.

< MILKY DIET
All mammals possess mammary glands. Unique to the class Mammalia, this feature is synapomorphic at this taxonomic level. To find further familial relationships within the class, characters that are synapomorphic at familial level are used.

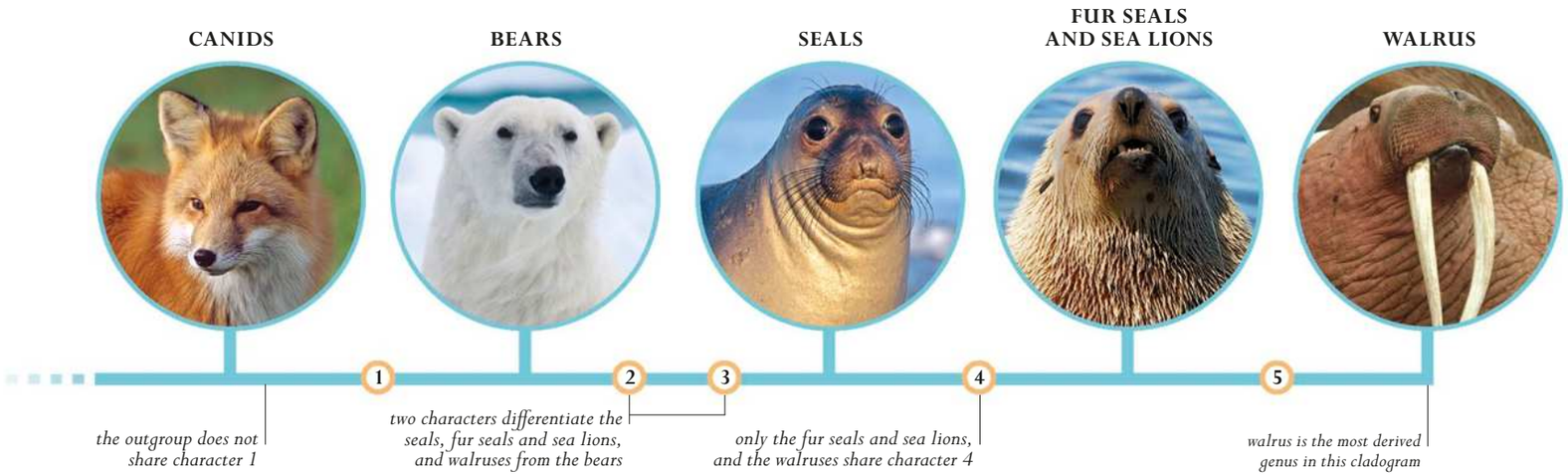
CHARACTER	CANID	BEAR	SEAL	FUR SEAL & SEA LION	WALRUS
Feeding young on milk	1	1	1	1	1
Short tail	0	1	1	1	1
Forelimbs modified into flippers	0	0	1	1	1
Very flexible spine	0	0	1	1	1
Hind limbs turn forwards under body	0	0	0	1	1
Presence of tusks	0	0	0	0	1

< CHARACTER SET
Most modern cladograms are based on genetics using DNA codes. The codes that were used to generate the cladogram below have been replaced with more familiar morphological descriptions in this character set. One character, feeding young on milk, is shared by all the groups shown; some characters are found in only some of the groups; and one character, the presence of tusks, is unique to the walrus.

v CLADOGRAM
In this cladogram the canids are considered the most primitive group, known as the outgroup, and the walrus is the most derived. All characters on the cladogram are shared by the groups to the right of each number – for example, a short tail is shared by the bears, seals, fur seals and sealions, and the walrus.

KEY

0	primitive character
1	derived character

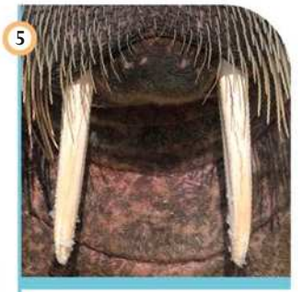

CANIDS
BEARS
SEALS
FUR SEALS AND SEA LIONS
WALRUS
1
2
3
4
5
the outgroup does not share character 1
two characters differentiate the seals, fur seals and sea lions, and walruses from the bears
only the fur seals and sea lions, and the walruses share character 4
walrus is the most derived genus in this cladogram

SHORT TAIL
Bears, seals, fur seals and sea lions, and the walrus all have short tails (character 1). Canids, however, display the primitive condition and have long, bushy tails. Character 1 is therefore a synapomorphic character shared by all the carnivore families shown except the canids.

FLIPPERS
Among carnivores, the modified limbs of seals, fur seals and sea lions, and the walrus are unique. Character 2 (forelimbs modified into flippers) is therefore synapomorphic at this level, suggesting these three groups are more closely related to one another than to the bears.

FLEXIBLE SPINE
Character 3 (flexible spine) operates at the same level as character 2, further supporting the relationship indicated by possession of flippers. The more synapomorphic characters that appear at a particular level, the more convincing the suggested relationship becomes.

SUPPORTING LIMBS
In both the fur seals and sea lions and the walrus, the pelvic girdle can be rotated to allow the hind limbs to aid locomotion on land. This suggests they share a more recent common ancestor with each other than they do with the seals, which are far less mobile when out of water.



TUSKS
This is a unique character (autapomorphy) of the walrus that reveals nothing about its relationship to other mammal families. The same is true of the character "feed young on milk" – present in all the groups, it provides no clues as to how they interrelate, so it is not plotted on the cladogram.

TREE OF LIFE

Using a branching tree as a way of showing the diversity of life was first suggested by the German naturalist Peter Pallas in 1766. Since then many such trees have been constructed. Initially tree-like, complete with bark and leaves, they later became more diagrammatic, and took account of evolutionary theories. Modern, computer-generated trees of life present many different ideas of how living organisms are related.

DARWIN'S FIRST TREE

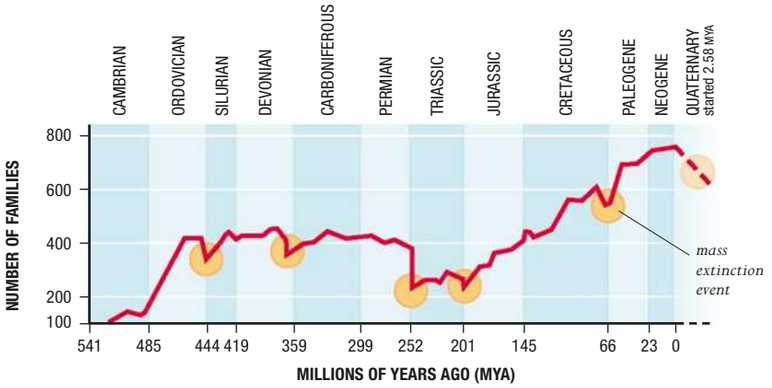
The first person to produce a tree of life that reflected the concept of evolution was Charles Darwin. He sketched the first of his ten evolutionary trees of life in 1837. It was a simple branching diagram, which he developed further before publishing it in the *Origin of Species* in 1859. The lettered branches show how he thought his theory might work – the more branch points separating an organism from its ancestor (numbered 1), the more different the organism will be. In 1879, Ernst Haeckel took the idea further, with a tree that showed animals evolving from single-celled organisms. Today, DNA and protein analyses as well as morphology are used to construct evolutionary trees and establish the genetic relationships between organisms. Vast data sets require computers to generate the trees, which are continually refined as new species and information are discovered.

Traditionally, trees of life emphasised vertebrate groups and relationships as those of the microscopic archaea and bacteria, and protoctists (those eukaryotes not classified as plants, animals, or fungi) were more problematic. However, modern genomic studies have revealed an extraordinary diversification and complexity of relationships within the bacteria and within the early, or basal, eukaryote groups.

MASS EXTINCTIONS

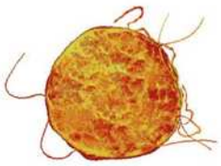
Mapping all life forms that have ever existed on a tree is difficult as, over time, more than 95 per cent of all species have become extinct. A mass extinction occurs when a large number of species dies off at the same time. This has happened five times in the past. The best-known extinction, which wiped out the dinosaurs, occurred at the end of the Cretaceous Period; it is thought to have been caused by a meteor impact combined with volcanic activity. As habitats are rapidly destroyed by human activity, it is likely that there will be another extinction event in the future.

EXTINCTION TIMELINE



READING THE TREE

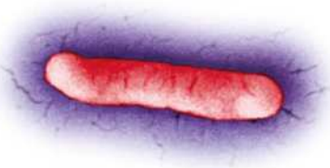
This diagram shows how life evolved from simple organisms, such as the Archaea – which appeared about 3.4 billion years ago – to complex life forms, such as animals, which appeared about 650 million years ago. It also shows the diversity of the vertebrates (see pp.34–35), which have a disproportionate representation here. The circles indicate points where two or more groups of organisms have branched from a common ancestor at about the same time. Only extant species are shown, so extinct groups, such as the reptilian dinosaurs, are missing.



LIFE BEGINS

ARCHAEA

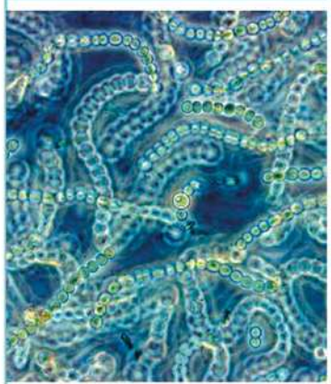
BACTERIA



STRUCTURE OF LIFE

All forms of life belong to one of three domains: Archaea, Bacteria, and Eukaryota. Archaea and bacteria are unicellular and lack a cell nucleus – they used to be classified together as Prokaryota. Eukaryotic organisms tend to be multicellular and each cell contains a nucleus, within which DNA is stored. This table shows the three domains and the four eukaryote kingdoms. Despite appearances, the Archaea and Bacteria are the largest groups – although only about 20,000 species have been described, estimates exceed 4 million species. Among eukaryotes, the groups that make up the protoctists and invertebrates are far more numerous in terms of species than vertebrate groups.

ARCHAEA	**EUKARYOTES**
BACTERIA	**PROTOCTISTS**
	PLANTS
	MOSSES
	LIVERWORTS
	HORNWORTS
	LYCOPHYTES
	FERNS AND RELATIVES
	CYCADS, GINKGOS, AND GNETOPHYTES
	CONIFERS
	FLOWERING PLANTS
	FUNGI
	MUSHROOMS
	SAC FUNGI
	LICHENS
	ANIMALS
	INVERTEBRATES
	CHORDATES



CYANOBACTERIA

SAC FUNGI, YEASTS

GLOMEROMYCETES

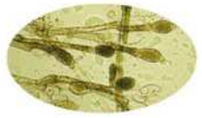
CHYTRIDIOMYCETES

NEOCALLIMASTIGOMYCETES

LICHENS

Lichens are classified according to the fungal half of the partnership

MUSHROOMS, RUSTS, & SMUTS



BLASTOCLADIOMYCETES

ZYGOMYCETES

AMOEBOZOANS

FUNGI

CHOANOFLAGELLATES

ANIMALS »

EUKARYOTES

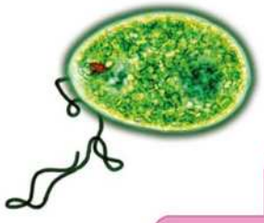
PROTOCTISTS

OPISTHOKONTANS

EXCAVATES

KINETOPLASTIDS

EUGLENIDS



HORNWORTS

LYCOPHYTES

EUDICOTS

LIVERWORTS

MAGNOLIIDS

FERNS & RELATIVES

STONEWORTS & RELATIVES

RHIZARIANS

BROWN ALGAE

RADIOLARIANS

PLANTS

FLOWERING PLANTS

GREEN ALGAE

MOSSES

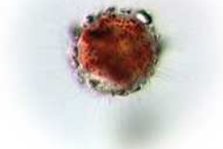
CYCADS, GINKGOS, GNETOPHYTES

WATER MOULDS

RED ALGAE

MONOCOTS

FORAMINIFERANS



HETEROKONTS

CONIFERS

CERCOZOANS

GYMNOCHLORA STELLATA

DIATOMS

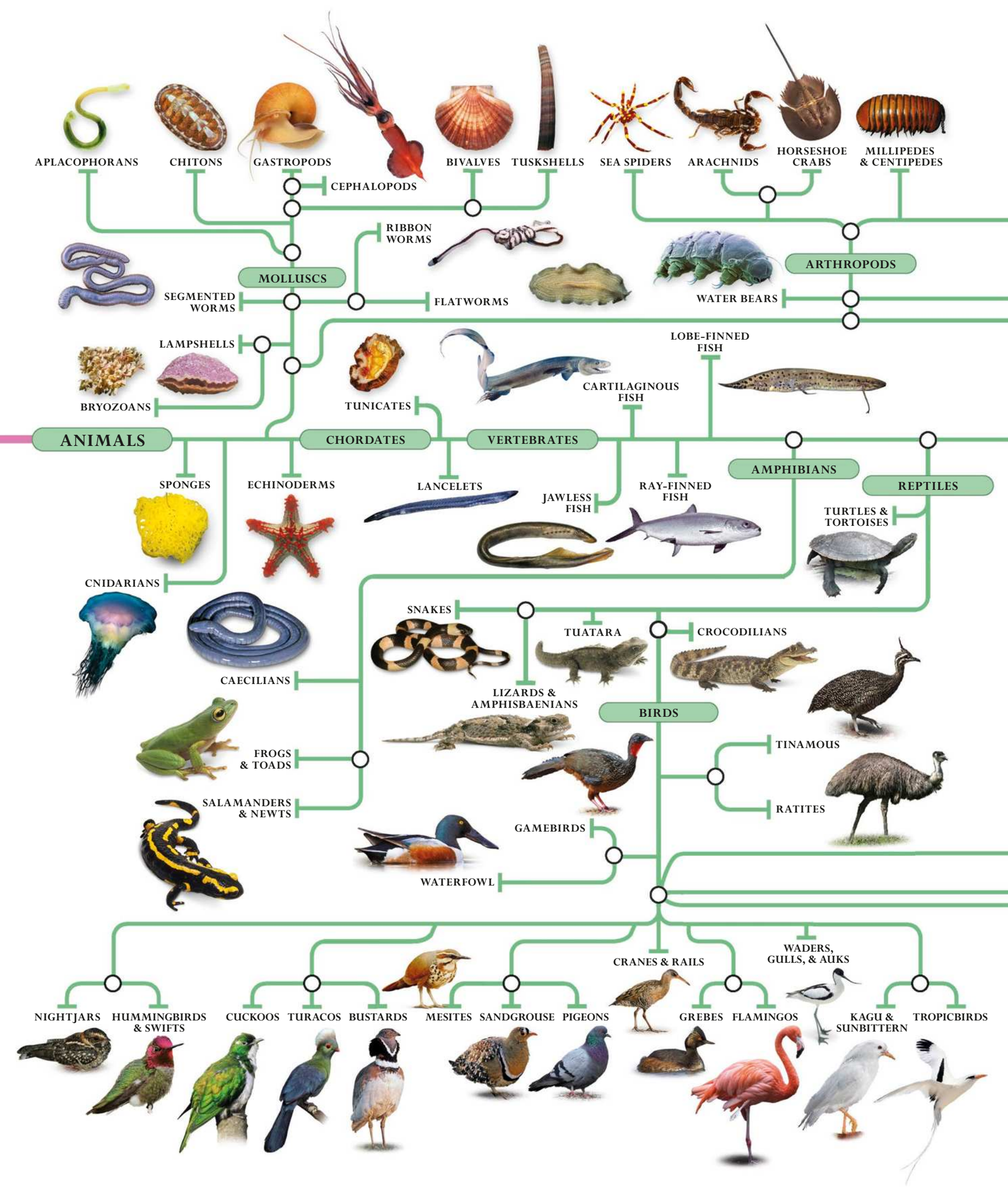
ALVEOLATES

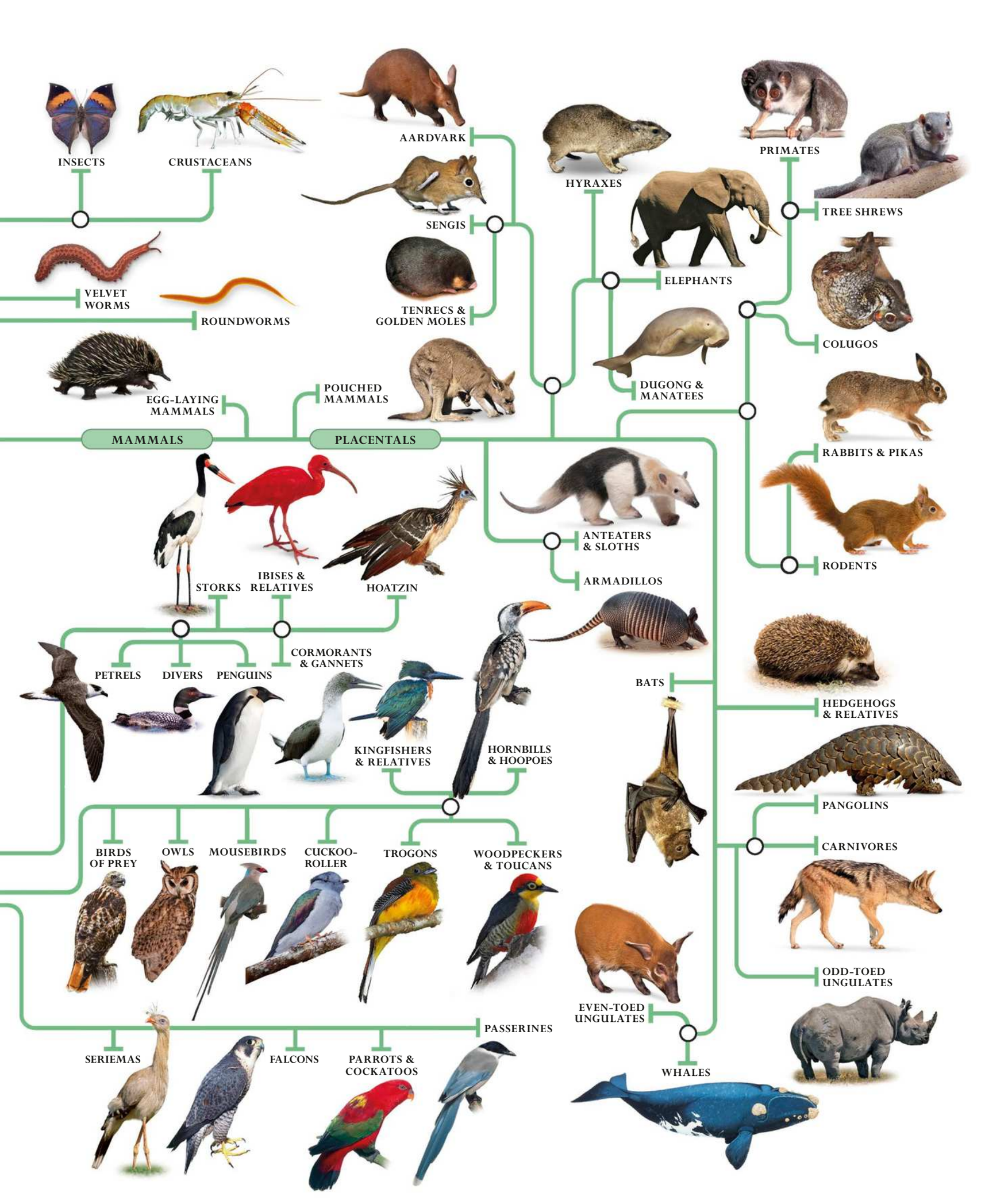
APICOMPLEXANS

DINOFLAGELLATES

CILIATES

BASAL FAMILIES


APLACOPHORANS
CHITONS
GASTROPODS
CEPHALOPODS
BIVALVES
TUSKSHELLS
SEA SPIDERS
ARACHNIDS
HORSESHOE CRABS
MILLIPEDES & CENTIPEDES
RIBBON WORMS
MOLLUSCS
SEGMENTED WORMS
FLATWORMS
ARTHROPODS
WATER BEARS
LAMPSHELLS
BRYOZOANS
TUNICATES
CARTILAGINOUS FISH
LOBE-FINNED FISH
ANIMALS
CHORDATES
VERTEBRATES
SPONGES
ECHINODERMS
LANCELETS
JAWLESS FISH
RAY-FINNED FISH
AMPHIBIANS
REPTILES
TURTLES & TORTOISES
CNIDARIANS
SNAKES
TUATARA
CROCODILIANS
CAECILIANS
LIZARDS & AMPHISBAENIANS
BIRDS
FROGS & TOADS
TINAMOUS
SALAMANDERS & NEWTS
RATITES
GAMEBIRDS
WATERFOWL
CRANES & RAILS
WADERS, GULLS, & AUKS
NIGHTJARS
HUMMINGBIRDS & SWIFTS
CUCKOOS
TURACOS
BUSTARDS
MESITES
SANDGROUSE
PIGEONS
GREBES
FLAMINGOS
KAGU & SUNBITTERN
TROPICBIRDS


INSECTS
CRUSTACEANS
AARDVARK
SENGIS
VELVET WORMS
ROUNDWORMS
TENRECS & GOLDEN MOLES
EGG-LAYING MAMMALS
POUCHED MAMMALS
MAMMALS
PLACENTALS
HYRAXES
PRIMATES
TREE SHREWS
ELEPHANTS
COLUGOS
DUGONG & MANATEES
RABBITS & PIKAS
RODENTS
ANTEATERS & SLOTHS
ARMADILLOS
STORKS
IBISES & RELATIVES
HOATZIN
CORMORANTS & GANNETS
PETRELS
DIVERS
PENGUINS
KINGFISHERS & RELATIVES
HORNBILLS & HOOPOES
BATS
HEDGEHOGS & RELATIVES
PANGOLINS
CARNIVORES
ODD-TOED UNGULATES
EVEN-TOED UNGULATES
WHALES
BIRDS OF PREY
OWLS
MOUSEBIRDS
CUCKOO-ROLLER
TROGONS
WOODPECKERS & TOUCANS
PASSERINES
SERIEMAS
FALCONS
PARROTS & COCKATOOS

MINERA
ROCKS,
FOSSILS

LS, &

Life on Earth is shaped by the rocks that lie beneath our feet. Made of different combinations of minerals, they have a far-reaching influence on the landscape, on vegetation, and on the soil. Preserved within these rocks, fossils form a highly detailed record of life in the distant past, showing the path that evolution has followed over hundreds of millions of years.

» 38

MINERALS

The building blocks of rocks, minerals typically have a crystalline structure. Several thousand exist in Earth's crust, but fewer than 50 minerals are common and widespread.

» 62

ROCKS

Classified according to how they formed, rocks are constantly broken down and reformed. The oldest rocks date back 3.8 billion years, when Earth's crust first solidified.

» 74

FOSSILS

Most fossils preserve hard remains, such as teeth and bones. They can also include traces such as footprints, and carbon impressions in rock, which reveal the past existence of living things.

MINERALS

Minerals are the materials from which rocks are made. More than 4,000 different minerals exist, each one with its own chemical composition, found naturally on Earth. Many minerals are hard and crystalline, and, while some are extremely abundant, others – including diamond – are very rare, and highly prized.

Copper often appears in a dendritic form, branching like a tree. It is a very important economic mineral.

Malachite can be botryoidal, with small, rounded shapes, or massive, with no definite shape.

Crocoite, which is lead chromate, frequently occurs as slender, elongated prismatic crystals.

Minerals are of great economic significance. They provide us with countless useful materials, from metals to industrial catalysts, and they also include objects of great intrinsic beauty, particularly when cut and polished as gems. But on an even broader scale, minerals are essential for life itself. In soil and in water, soluble minerals release a steady stream of chemical nutrients that plants and other organisms need to grow. Without them, the world's ecosystems would no longer operate.

Minerals are classified according to their chemistry. A few minerals, such as gold, silver, and sulfur, can exist in a native state, meaning they contain a pure chemical element, and nothing else. All other minerals are chemical compounds. Quartz, for example, contains two elements – silicon and oxygen – which are bound together very tightly, giving quartz its exceptional hardness and strength. Under the Strunz classification system, quartz (silicon dioxide) is classified as an oxide, as are chalcedony and opal, but under the Dana system, used in this book, they are included with the silicates. The largest group of minerals, the silicates make up about 75 per cent of Earth's crust. Other common mineral groups include sulfides, oxides, carbonates, arsenates, and halides.

IDENTIFYING MINERALS

With experience, many minerals can be identified by their appearance alone. Important clues include their colour, their lustre – the way light is reflected from their surfaces – and above all, their habit, and/or crystal form. Crystals are grouped into six systems according to their symmetry (see panel, below). Minerals do not always occur as crystals but can take different forms: they can be dendritic (branching), or botryoidal (like a bunch of grapes), for example.

Minerals also differ in density, or specific gravity (SG) – measured by comparing the weight of a mineral to that of an equal volume of water – and in their hardness (H). On the 10-point Mohs scale, which measures hardness, talc is rated 1, whereas diamond, the hardest mineral, is rated 10. A fingernail (hardness 2½), copper coin (3½), and steel knife blade (5½) all make useful benchmarks for testing hardness. Surprisingly, size is not a useful clue. Gypsum crystals, for example, are usually less than 1 cm (⅜ in) long, but the largest specimens ever discovered are the size of a two-storey house.

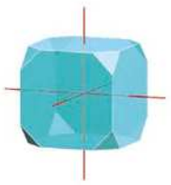
VOLCANIC MINERALS >
The ground at Dallol in Ethiopia's Danakil Desert is pock-marked by volcanic vents and covered in sulfur, a native element.

DEBATE

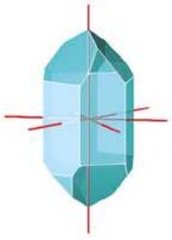
MINERALS OR NOT?

Minerals are traditionally considered to be inorganic. Although some organic materials are used as gemstones and for other decorative purposes, and some of these have a similar chemical composition to minerals, they are not true minerals. Amber is the hardened resin from trees; much amber is of Cretaceous, Palaeogene, and Neogene age and can contain fossilized insects. Jet, a soft black rock, is a type of impure coal, and became highly fashionable for jewellery in Victorian times. Shell, pearl, and coral (the use of which is not sustainable) are rich in calcite and are used decoratively.

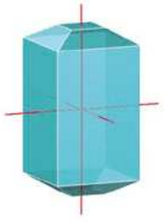
CRYSTAL SYSTEMS



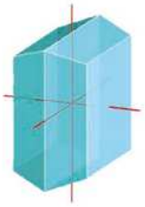
Crystals in the **cubic** system are relatively common and easily recognized. Such crystals have three equal axes at right angles; shapes include the cube and the eight-faced octahedron.



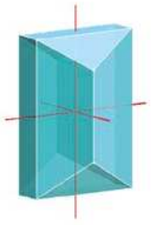
Hexagonal and trigonal systems are very similar to each other, with four axes of symmetry. Their crystals are often six-sided prisms with pyramidal tops (left).



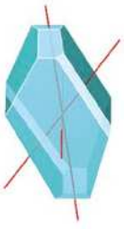
Crystals in the **tetragonal** system have three axes of symmetry, all at right angles. In a tall prism (left), the vertical axis is the longest. Squat prisms are also common.



Crystals in the **monoclinic** system have three unequal axes of symmetry, only two at right angles. Tabular (flattened, left) and prismatic habits are common.



Crystals in the **orthorhombic** system are similar to those in the monoclinic system, but all three axes are at right angles; the usual habits are tabular and prismatic (left).



Crystals in the **triclinic** system have a low degree of symmetry, as the three axes are unequal in length, with no right angles between them. Prismatic habits are common.

NATIVE ELEMENTS

Of the many natural elements, only about 20 are found in the native state; that is, uncombined with other elements. They are divided into three groups. The metals rarely form as distinct crystals, tend to have a high specific gravity, and are relatively soft. Semimetals, such as antimony and arsenic, commonly occur as rounded masses. Nonmetals, including sulfur and carbon, often form as crystals.

ANTIMONY
Trigonal
H 3–3½ • SG 6.69
This rare semimetal occurs in hydrothermal veins, often with arsenic and silver minerals. The silvery grey masses are coated white when oxidized.

GRAPHITE
Hexagonal • H 1–2 • SG 2.09–2.23
A form of pure carbon common in metamorphic rocks, graphite is dark, soft, and greasy, and makes ideal pencil leads.

NATIVE COPPER

COPPER
Cubic • H 2½–3 • SG 8.94
Native copper occurs mainly as irregular masses or branching or wire-like forms. It is most notably associated with basaltic lava. A good conductor, it is widely used in the electrical industry.

COPPER ON GOETHITE GROUNDMASS

dendritic habit

distinct, isolated diamond crystal

DIAMOND
Cubic • H 10 • SG 3.51
The hardest of all minerals, diamond, a valuable form of carbon, occurs in igneous rocks called kimberlites, which originate in deep volcanic pipes.

rock groundmass

resinous lustre

ARSENIC
Trigonal • H 3½ • SG 5.72–5.73
Highly poisonous arsenic usually forms as pale grey, rounded masses in hydrothermal veins. If heated, it smells of garlic.

SULFUR
Orthorhombic • H 1½–2½ • SG 2.07
Native sulfur forms striking yellow crystals and powdery crusts around volcanic vents. It is mined for use in sulfuric acid, dyes, insecticides, and fertilizers.

PLATINUM NUGGET

PLATINUM
Cubic • H 4–4½ • SG 21.44
A rare metal, native platinum forms as scales, grains, and nuggets in igneous rocks and is found in alluvial sands. Its high melting point means it is useful in industry, for example in aircraft spark plugs.

uneven surface

PLATINUM

SULFIDES

The sulfides are a large group of minerals, in which sulfur is combined with one or more metals. Many sulfides have a high specific gravity and a metallic lustre. They often form as excellent crystals. Sulfides occur in many geological situations, but frequently in hydrothermal veins. The group includes the majority of the economically important metal ore minerals.

GOLD IN QUARTZ

GOLD NUGGET

GOLD
Cubic • H 2½–3 • SG 19.3
Prized for its colour and malleability, gold forms in hydrothermal veins and often weathers out to be found as nuggets in river sands.

IRON
Cubic • H 4½ • SG 7.3–7.87
Most native iron occurs at Earth's core, and near the surface it readily combines with other elements.

BISMUTH
Trigonal
H 2–2½ • SG 9.7–9.83
Native bismuth is relatively rare. Hardly ever found as distinct crystals, it more often has a granular or branching form.

mercury globules in rock cavities

MERCURY
Trigonal
H Liquid • SG 14.38
This is the only metal that is liquid at normal temperatures. In liquid form, mercury appears as silvery globules.

SILVER
Cubic • H 2½–3 • SG 10.5
Widely distributed but rarely found in abundance, native silver occurs mainly as twisted wires, scales, and branching masses.

COBALTITE
Orthorhombic • H 5½ • SG 6.33
Cobaltite is an uncommon sulfide of arsenic and cobalt. It is an important cobalt ore in, for example, Sweden and Norway.

long, curved crystals resemble blades or swords

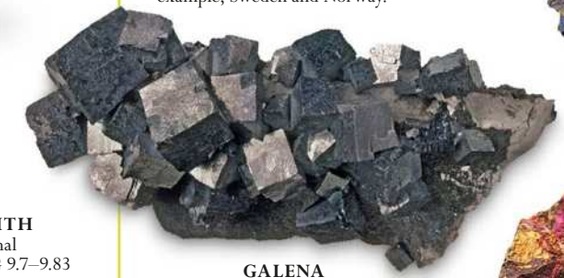
STIBNITE
Orthorhombic • H 2 • SG 4.63–4.66
A sulfide of antimony, this dark grey mineral is the main ore of antimony. Large deposits occur in China, Japan, and W. USA.

indistinguishable crystals form large masses

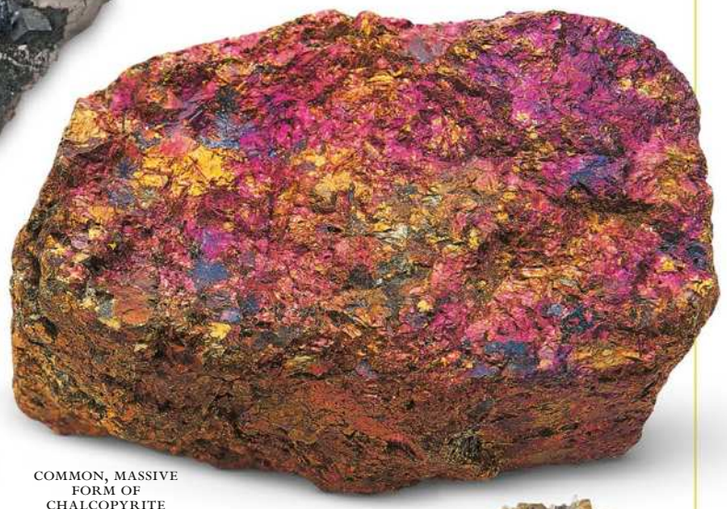
MASSIVE BORNITE

BORNITE CRYSTALS

BORNITE
Orthorhombic • H 3 • SG 5.08
This copper iron sulfide is a coppery red colour, tarnishing to shimmering purple and blue. It is an important copper ore.



GALENA
Cubic • H 2½ • SG 7.58
Lead sulfide is one of the more abundant and widely distributed sulfide minerals. It is mined extensively as lead ore.



COMMON, MASSIVE FORM OF CHALCOPYRITE

GREENOCKITE
Hexagonal
H 3–3½ • SG 4.82
Named after Lord Greenock, on whose Scottish property it was discovered in 1840, this rare cadmium sulfide can be yellow, red, or orange.

CHALCOPYRITE
Tetragonal
H 3½–4 • SG 4.35
A sulfide of copper and iron, chalcopyrite has a deep brassy yellow colour. It has significant value as a copper ore.

CHALCOPYRITE CRYSTALS

USUAL, CRYSTALLINE FORM OF SPHALERITE

MASSIVE SPHALERITE

SPHALERITE
Cubic • H 3½–4 • SG 3.9–4.1
A sulfide of zinc with variable iron content, sphalerite is the most heavily mined zinc-containing ore.

ACANTHITE
Monoclinic
H 2–2½ • SG 7.22
A sulfide occurring as dark, metallic, sometimes spiky crystals, acanthite is the main ore of silver.

CINNABAR
Trigonal
H 2–2½ • SG 8–8.2
Red-coloured mercury sulfide has been the main source of mercury through the centuries. It occurs around hot springs and volcanic vents.

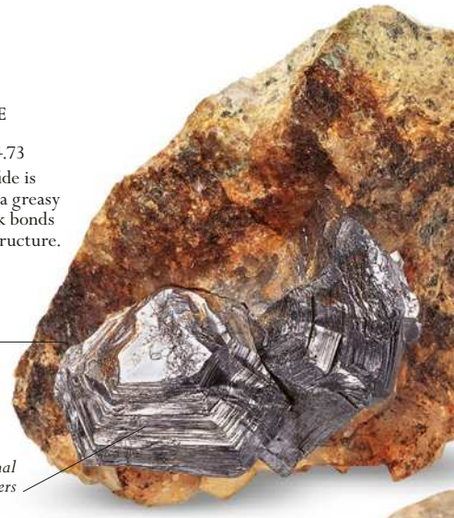
» SULFIDES

ORPIMENT
Monoclinic
H 1½–2 • SG 3.49
Named from the Latin for "golden paint", this arsenic sulfide occurs as foliated, columnar masses around hot springs.

REALGAR
Monoclinic • H 1½–2 • SG 3.56
A bright orange-red sulfide of arsenic, realgar was historically used as a pigment.

GLAUCODOT
Orthorhombic • H 5 • SG 6.05
This sulfide of cobalt, iron, and arsenic occurs as silver-white pyramidal crystals and brittle masses.

MOLYBDENITE
Hexagonal
H 1–1½ • SG 4.62–4.73
This molybdenum sulfide is lead-grey in colour. It has a greasy feel, which is due to weak bonds within a layered atomic structure.



MARCASITE
Orthorhombic
H 6–6½ • SG 4.89
A sulfide of iron that is lighter and more brittle than pyrite, marcasite frequently occurs as cockscombs and spear-shaped "twins".

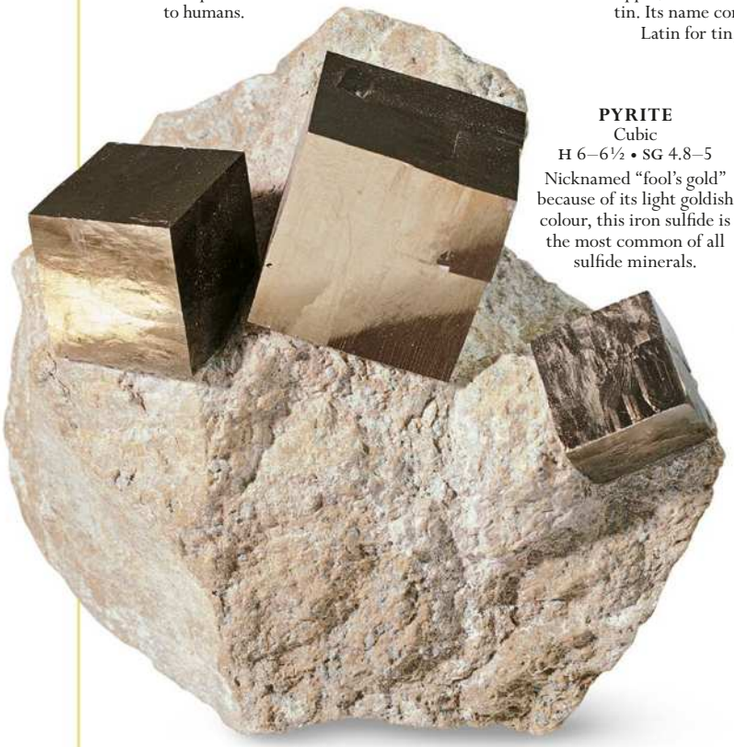
COVELLITE
Hexagonal • H 1½–2 • SG 4.68
Although covellite is rare, it is a widespread copper sulfide. Its shining indigo-blue colour makes it attractive to mineral collectors.

HAUERITE
Cubic • H 4 • SG 3.46
Hauerite is a very rare sulfide of manganese. The brown octahedral crystals can form when certain minerals are altered in the caps of salt domes.

ARSENOPYRITE
Monoclinic
H 5½–6 • SG 6.07
Silvery-coloured arsenopyrite is a sulfide of arsenic and iron. With almost 50 per cent arsenic content, it is a principal ore of arsenic which is poisonous to humans.

STANNITE
Tetragonal • H 4 • SG 4.3–4.5
Stannite is a sulfide of tin, copper, and iron mined for the tin. Its name comes from the Latin for tin, *stannum*.

PENTLANDITE
Cubic
H 3½–4 • SG 4.6–5
This nickel and iron sulfide is found in basic igneous rocks. It is an important source of nickel.



PYRITE
Cubic
H 6–6½ • SG 4.8–5
Nicknamed "fool's gold" because of its light goldish colour, this iron sulfide is the most common of all sulfide minerals.

PYRRHOTITE
Monoclinic • H 3½–4½ • SG 4.58–4.65
An iron sulfide with variable iron content, pyrrhotite has a magnetism that increases as the iron content decreases.

MILLERITE
Trigonal
H 3–3½ • SG 5.3–5.5
This sulfide of nickel occurs in limestones and ultramafic rocks. It is sought after as a nickel ore.

CHALCOCITE
Monoclinic • H 2½–3 • SG 5.5–5.8
Dark grey to black in colour, this copper sulfide has been mined for centuries. It is one of the most profitable copper ores.

BISMUTHINITE
Orthorhombic • H 2 • SG 6.78
This sulfide of bismuth is an important ore. Much of the bismuth recovered is used in medicines and cosmetics.

SULFOSALTS

Sulfosalts are a group of about 200 minerals, structurally related to sulfides and with many of the same properties. In these compounds sulfur is combined with a metallic element – commonly silver, copper, lead, or iron – and a semimetal, often antimony or arsenic. Sulfosalts frequently occur in hydrothermal veins, usually in small amounts.

PYRARGYRITE
Trigonal
H 2½ • SG 5.85
Also called ruby silver, this sulfide of silver and antimony is red-black, but thin splinters appear deep ruby-red.

POLYBASITE
Monoclinic
H 2½–3 • SG 6.1
Somewhat uncommon, polybasite is a sulfide of silver, copper, antimony, and arsenic. It can yield worthwhile quantities of silver locally.

BOULANGERITE
Monoclinic
H 2½–3 • SG 6.2
A bluish grey sulfide of lead and antimony, boulangerite is one of few sulfide minerals to form fine, hair-like crystals.

STEPHANITE
Orthorhombic
H 2–2½ • SG 6.26
Stephanite is an opaque black sulfide of silver and antimony. It can be an important silver ore – for example, in Nevada, USA.

striated prismatic crystals

JAMESONITE
Monoclinic • H 2½ • SG 5.63
A sulfide of lead, iron, and antimony, jamesonite's dark grey crystals can be fine and hair-like or larger and prismatic.

PROUSTITE
Trigonal • H 2–2½ • SG 5.55–5.64
This sulfide of silver and arsenic is also called light ruby silver. The transparent crystals are bright scarlet-red.

ZINKENITE
Hexagonal
H 3–3½ • SG 5.25–5.35
Zinkenite is a sulfide of lead and antimony. It occurs as steel-grey hair- or needle-like crystals.

TETRAHEDRITE
Cubic
H 3–4½ • SG 4.6–5.1
This sulfide of copper, iron, and antimony is named after its tetrahedron-shaped crystals (crystals with four triangular faces).

TENNANTITE
Cubic • H 3–4½ • SG 4.59–4.75
Tennantite, a sulfide of copper, iron, and arsenic, is dark grey or black. It is very similar to tetrahedrite.

ENARGITE
Orthorhombic • H 3 • SG 4.45
A steel-grey coloured sulfide of copper and arsenic, enargite has a metallic lustre. Crystals are usually small, tabular, or prismatic.

BOURNONITE
Orthorhombic • H 2½–3 • SG 5.83
Black or steel-grey bournonite is a sulfide of lead, copper, and antimony. Crystals are tabular to prismatic.

OXIDES

Oxides are compounds of oxygen and other elements. Many oxides are very hard, some have a high specific gravity, and a number are brightly coloured and are sought after as gems. The group includes the chief ores of iron, manganese, aluminium, tin, and chromium. Oxides can occur in hydrothermal veins, igneous and metamorphic rocks, and also, because they can be resistant to weathering and transport, in sands and gravels.

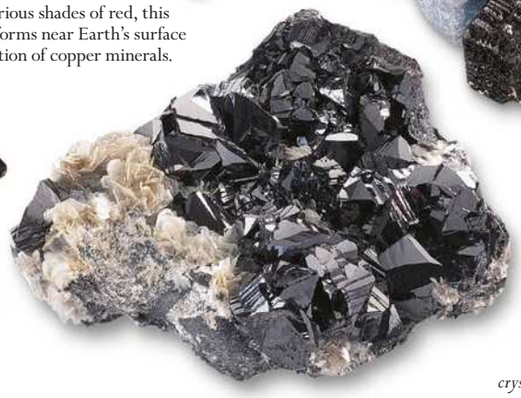
CUPRITE
Cubic • H 3½–4 • SG 6.14
Found in various shades of red, this copper oxide forms near Earth's surface by the oxidation of copper minerals.

PEROVSKITE
Orthorhombic
H 5½ • SG 3.98–4.26
Discovered in Russia in 1839, this dark-coloured oxide of calcium and titanium forms in igneous and metamorphic rocks.

ILMENITE
Trigonal
H 5–6 • SG 4.68–4.76
This iron titanium oxide is the principal ore of titanium, a high strength, low density metal used in aircraft and rocket construction.

FRANKLINITE
Cubic
H 5½–6 • SG 5.07–5.22
This black or brown zinc iron oxide is found in metamorphosed limestones, notably those at Franklin, New Jersey, USA.

octahedral franklinite crystal



CASSITERITE
Tetragonal • H 6–7 • SG 6.98–7.01
Almost the sole source of the world's tin, this tin oxide is mainly found in hydrothermal veins and pegmatites and sometimes as small grains among river gravels.

URANINITE
Cubic • H 5–6 • SG 10.63–10.95
This highly radioactive, black- or brown-coloured uranium oxide is the main ore of uranium, which is used in nuclear reactors to produce electricity, and in the construction of nuclear weapons.

SAMARSKITE
Monoclinic
H 5–6 • SG 5–5.69
Minerals known as samarskite – a radioactive oxide of various metals including yttrium, iron, tantalum, and niobium – occur in igneous rocks and alluvial sands.

GAHNITE
Cubic • H 7½–8 • SG 4.62
A rare oxide of aluminium and zinc found mainly in metamorphic rocks, gahnite can form dark green or blue to black crystals.

CORUNDUM
Trigonal
H 9 • SG 3.98–4.1
Corundum is an aluminium oxide, second only in hardness to diamond. Ruby (red) and sapphire (usually blue) varieties are used as gemstones.

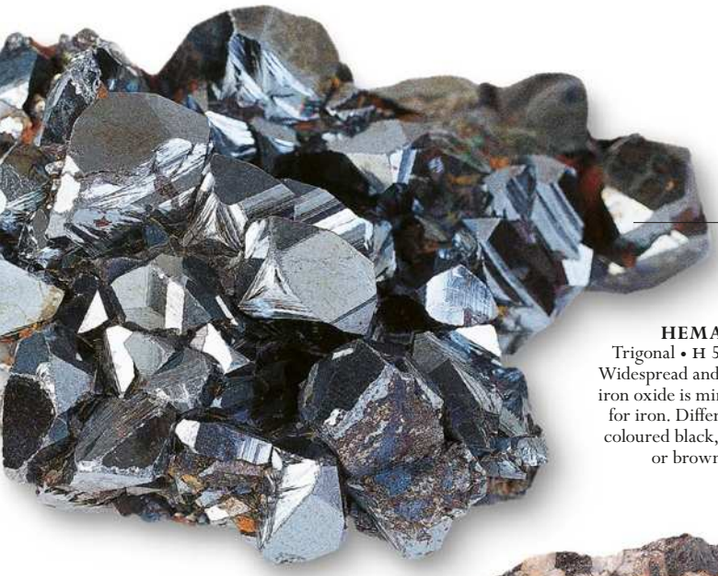
CHROMITE
Cubic • H 5½ • SG 4.5–4.8
This iron chromium oxide is the only important source of chromium, an element used in making chrome- and stainless-steel.

striated crystal face

vitreous lustre

HYDROXIDES

Hydroxide minerals are compounds of a metallic element and the hydroxyl radical (OH). They are common minerals and often form through a chemical reaction between an existing oxide and fluids rich in water, seeping through Earth's crust. Hydroxides tend to occur in the altered parts of hydrothermal veins and in metamorphic rocks.



HEMATITE
Trigonal • H 5–6 • SG 5.26
Widespread and abundant, this iron oxide is mined extensively for iron. Different forms are coloured black, metallic grey, or brownish red.

STIBICONITE
Cubic • H 5½–7 • SG 3.5–5.5
An uncommon hydroxide of antimony, stibiconite is white or yellowish brown, and forms by the alteration of other antimony minerals, especially stibnite.

GIBBSITE
Monoclinic
H 2½–3 • SG 2.38–2.42
Gibbsite is one of the essential aluminium hydroxides in the aluminium ore bauxite. It also occurs in hydrothermal veins.

FERGUSONITE
Tetragonal
H 5½–6½ • SG 4.2–5.8
Fergusonite is the group name for an oxide of many metals, including yttrium, lanthanum niobium, and cerium.

DIASPORE
Orthorhombic • H 6½–7 • SG 3.2–3.5
Diaspore is an aluminium hydroxide which is found in bauxite. It also occurs in marble and altered igneous rocks.

LEPIDOCROCITE
Orthorhombic • H 5
SG 4.05–4.13
This relatively rare iron hydroxide may occur with goethite. It is reddish brown and can form irregular and fibrous shapes.

CHRYSOBERYL
Orthorhombic • H 8½ • SG 3.75
Chrysoberyl is beryllium aluminium oxide. It is a prized gemstone, known for its exceptional hardness and yellow-brown colour.

PYROLUSITE
Tetragonal
H 2–6½
SG 5.04–5.08
Pyrolusite is a common manganese oxide. It is the primary ore of manganese, an essential element in steel production.

RUTILE
Tetragonal
H 6–6½ • SG 4.23
A source of titanium, this oxide of titanium often forms impressive displays of thin, translucent needles in quartz crystals.

ZINCITE
Hexagonal • H 4 • SG 5.64–5.68
Zincite is a rare oxide of zinc. Its only significant deposit in the USA has been exhausted.

MASSIVE ROMANÈCHITE

ROMANÈCHITE
Monoclinic • H 5–6 • SG 6.45
Dark and opaque, this oxide of manganese with barium is usually found in aggregates or in massive forms. Crystals are rare.

BOTRYOIDAL GOETHITE

LIMONITE

GOETHITE
Orthorhombic • H 5–5½ • SG 4.27–4.29
Goethite is a common iron hydroxide. A non-crystalline hydrated variety – limonite – gives a yellow-brown colour to soils and rocks.

BAUXITE
Amorphous mixture
H 1–3 • SG 2.3–2.7
The primary aluminium ore, bauxite is not a single mineral, but rather an assemblage of aluminium hydroxides and iron oxides.

BRUCITE
Trigonal • H 2½–3 • SG 2.39
Brucite is a magnesium hydroxide, and its colour is white, grey, blue, or green. It occurs in metamorphic rocks.

HALIDES

When metallic elements combine with halogen elements, halides are formed. The halogens are iodine, fluorine, chlorine, and bromine. Halide minerals are commonly very soft and of low specific gravity, often having crystals classified in the cubic system. Many of these minerals, such as halite and sylvite, form in evaporite sequences by the drying out of saline waters. Other halides – for example, fluorite – occur in hydrothermal veins.

YELLOW FLUORITE

PURPLE FLUORITE

SYLVITE
Cubic • H 2 • SG 1.99
Sylvite is a potassium chloride, a salt similar to halite. It occurs with halite in evaporite deposits. Sylvite is used to make potash fertilizers.

FLUORITE
Cubic • H 4 • SG 3.18
This calcium fluoride often forms transparent to translucent crystals of various colours. Large quantities are used for making hydrofluoric acid.

GREEN FLUORITE

CARNALLITE
Orthorhombic • H 2½ • SG 1.6
Carnallite is a hydrated chloride of magnesium and potassium, formed by the evaporation of saline water. It is important in fertilizer manufacture.

DIABOLEITE
Tetragonal • H 2½ • SG 5.42
A lead copper chloride hydroxide with a light to dark blue colour, diaboleite forms by the alteration of other minerals.

BOLEITE
Cubic • H 3–3½ • SG 5.05
Deep blue boleite is a rare hydroxide of lead, silver, copper, and chlorine. It occurs where lead and copper deposits have been altered.

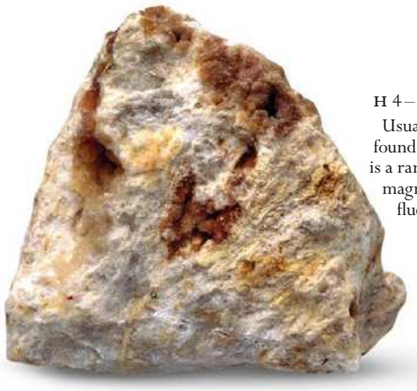
ORANGE HALITE

HALITE
Cubic • H 2 • SG 2.17
Halite (common salt), a sodium chloride, occurs in extensive beds formed by the evaporation of saline water. It can be coloured or colourless.

HALITE CRYSTALS

CARBONATES

Carbonate minerals are compounds of metallic or semimetallic elements combined with the carbonate radical (CO_3). Over 70 carbonate minerals are known, but calcite, dolomite, and siderite account for most of the carbonate material in Earth's crust. Carbonates usually form as "good" crystals with regular shapes and no foreign substances enclosed within them. Many carbonates are pale coloured, but some, such as rhodochrosite, smithsonite, and malachite, are brightly coloured.



JARLITE
Monoclinic
H 4–4½ • SG 3.78–3.93
Usually white, jarlite is found in igneous rocks. It is a rare sodium strontium magnesium aluminium fluoride hydroxide.

CHLORARGYRITE
Cubic • H 2½ • SG 5.55
This silver chloride is typically scaly, plate-like, or, in masses, resembling wax. It occurs where silver deposits are altered.

ATACAMITE
Orthorhombic • H 3–3½ • SG 3.76
Green atacamite is a copper chloride hydroxide, occurring where copper deposits have been oxidized. It is a minor copper ore.

CALOMEL
Tetragonal
H 1½–2 • SG 7.15
Rarely found, this mercury chloride is a white to grey or brown mineral. Its colour deepens on exposure to light.

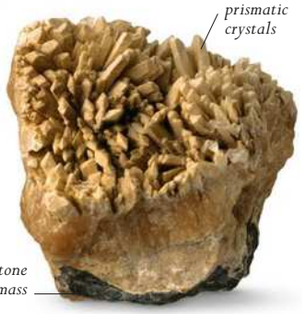
CRYOLITE
Monoclinic
H 2½ • SG 2.97
A rare aluminium sodium fluoride, cryolite often has an ice-like appearance. It is found in granitic pegmatites and granites.

TRONA
Monoclinic • H 2½ • SG 2.14
A hydrated sodium carbonate, trona is grey, yellowish, or brown. It forms at Earth's surface, especially in saline desert environments.

WITHERITE
Orthorhombic
H 3–3½ • SG 4.29
This fairly uncommon carbonate of barium is usually white or grey, and occurs in hydrothermal veins.

SMITHSONITE
Trigonal
H 4–4½ • SG 4.42–4.44
A zinc carbonate found in the upper oxidized zones of zinc ore deposits, smithsonite is also mined for zinc.

CALCITE
Trigonal
H 3 • SG 2.71
Most calcite (a calcium carbonate), one of the most abundant minerals, occurs in the rocks limestone and marble. It can also form outstanding crystals.



BARYTOCALCITE
Monoclinic • H 4 • SG 3.66–3.71
This barium calcium carbonate is white to yellowish, and often found in hydrothermal veins within limestone.

DOLOMITE
Trigonal
H 3½–4
SG 2.84–2.86
Dolomite is a calcium magnesium carbonate widespread in altered limestones. Dolomite rock, formed exclusively of massive dolomite, is used as a building stone.

MAGNESITE
Trigonal • H 3½–4½
SG 2.98–3.02
A magnesium carbonate, magnesite usually occurs as white to brownish dense masses. It is made into furnace bricks and magnesia cement.

STRONTIANITE
Orthorhombic • H 3½
SG 3.74–3.78
This strontium carbonate is found in hydrothermal veins and limestones. The strontium is used in sugar refining and fireworks.

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TWINNED ARAGONITE CRYSTALS

FLOS FERRI ("FLOWERS OF IRON") ARAGONITE

ARAGONITE
Orthorhombic
H 3½–4 • SG 2.95

Aragonite is a calcium carbonate, chemically identical to calcite, but in a different crystal system and much less common.

BOTRYOIDAL SIDERITE

SIDERITE
Trigonal
H 3½–4½ • SG 3.96

A brown-coloured carbonate of iron, named from the Greek for iron, *sideros*, siderite occurs in a variety of forms.

RHOMBOHEDRAL SIDERITE

short prismatic crystals

PHOSGENITE
Tetragonal • H 2–3 • SG 6.12–6.15

This rare lead carbonate chloride is formed close to Earth's surface by the reaction of lead-rich minerals with water.

ARTINITE
Monoclinic • H 2½ • SG 2.01–2.03

A hydrated magnesium carbonate hydroxide, artinite has a distinctive habit, with sprays of white, needle-shaped crystals. It occurs in serpentine rocks.

HYDROZINCITE
Monoclinic
H 2–2½ • SG 3.5–4

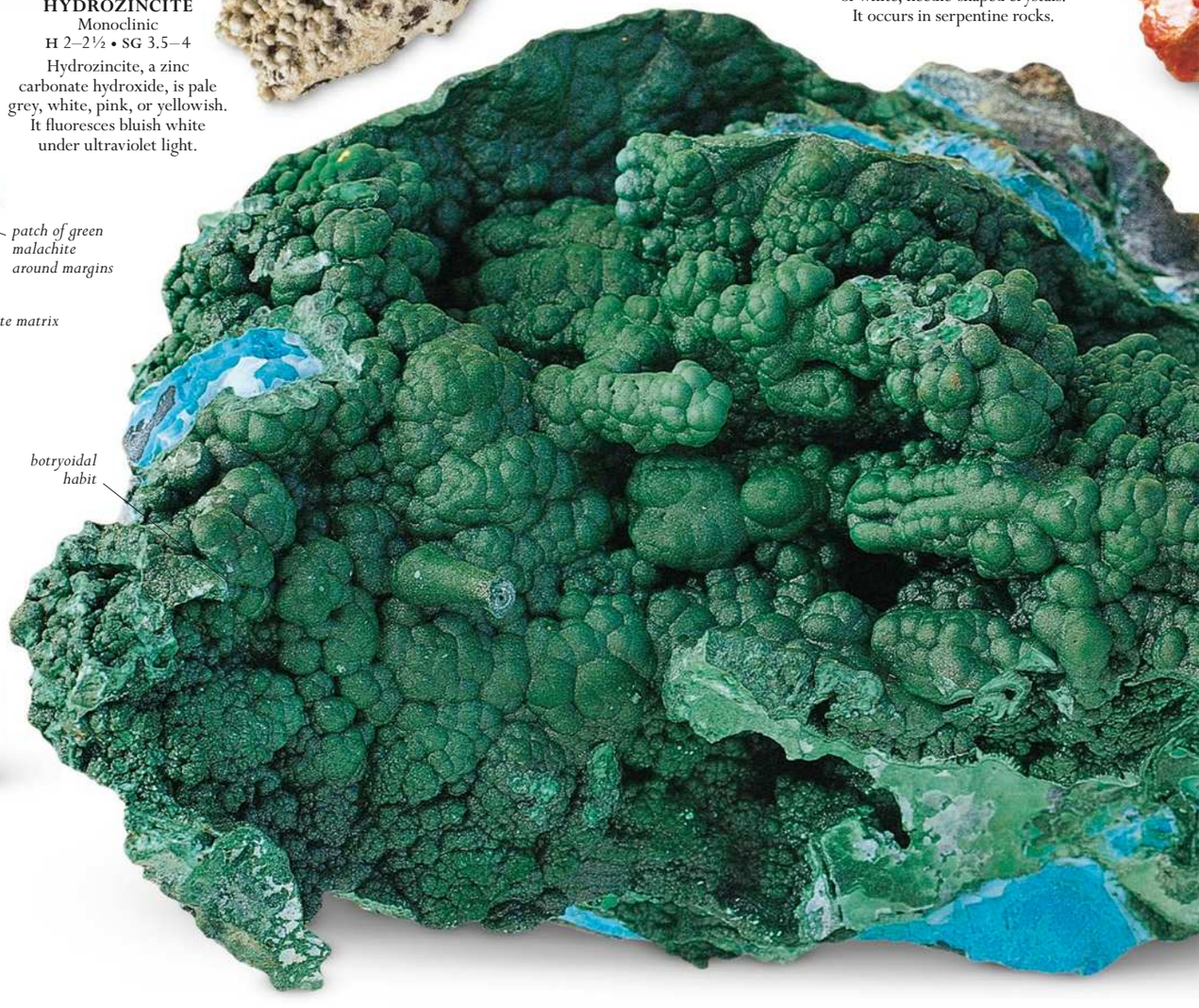
Hydrozincite, a zinc carbonate hydroxide, is pale grey, white, pink, or yellowish. It fluoresces bluish white under ultraviolet light.

patch of green malachite around margins

limonite matrix

AZURITE
Monoclinic • H 3½–4 • SG 3.77

Azurite is a hydrous copper carbonate. Its rich blue colour and frequent association with green malachite in hydrothermal veins are distinctive features.



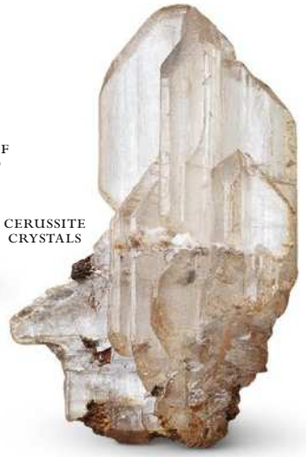
botryoidal habit

LEADHILLITE
Monoclinic • H 2½–3 • SG 6.55

This lead sulfate carbonate hydroxide usually occurs as well-formed crystals in the oxidized zones of lead deposits.

CLUSTER OF TWINNED CRYSTALS

CERUSSITE
Orthorhombic • H 3–3½ • SG 6.53–6.57
A carbonate of lead occurring where lead-bearing veins have been altered, cerussite is the most common lead ore after galena.



CERUSSITE CRYSTALS

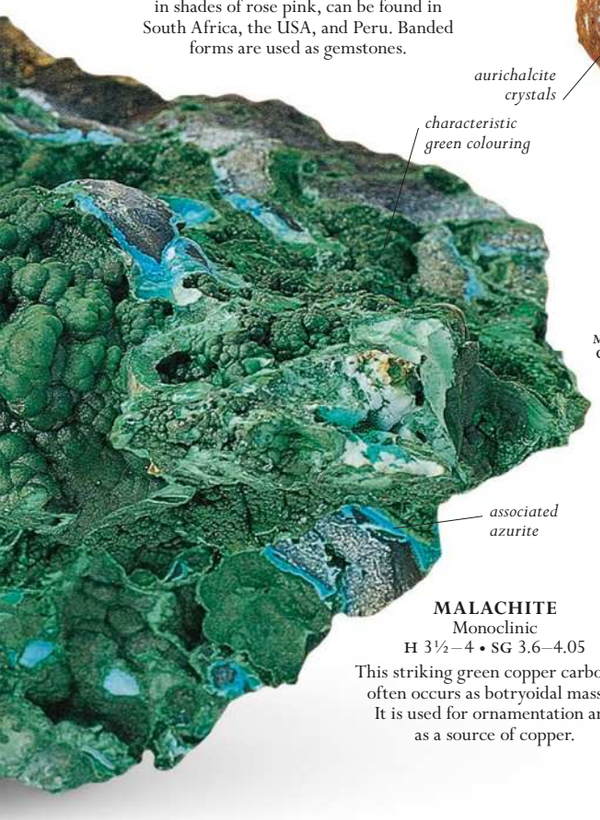
rhombohedral crystals

RHODOCHROSITE
Trigonal • H 3½–4 • SG 3.7
Fine crystals of this manganese carbonate, in shades of rose pink, can be found in South Africa, the USA, and Peru. Banded forms are used as gemstones.

ANKERITE
Trigonal
H 3½–4 • SG 2.97
Ankerite is a carbonate of calcium with lesser iron, magnesium, and manganese. It is sometimes found in gold-bearing quartz veins.

aurichalcite crystals

AURICHALCITE
Monoclinic • H 1–2 • SG 3.96
A blue- or green-coloured zinc copper carbonate hydroxide, aurichalcite forms in the oxidized zones of zinc and copper deposits.

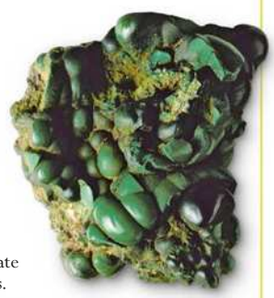


characteristic green colouring

associated azurite

MALACHITE
Monoclinic
H 3½–4 • SG 3.6–4.05
This striking green copper carbonate often occurs as botryoidal masses. It is used for ornamentation and as a source of copper.

MALACHITE ON CHRYSOCOLLA



BOTRYOIDAL MALACHITE

BORATES

Borates occur when metallic elements combine with the borate radical (BO_3). There are over 100 borate minerals, the most common being borax, kernite, ulexite, and colemanite. Borates tend to be pale coloured, relatively soft, and have low specific gravity. Many occur in evaporite sequences where saline waters have dried out and minerals are then precipitated among layers of sedimentary rocks.

KERNITE
Monoclinic • H 2½ • SG 1.91
A colourless or white sodium borate hydrate, kernite has less water than borax. The two minerals often occur together.

BORACITE
Orthorhombic
H 7–7½ • SG 2.91–3.1
Crystals of this magnesium borate chloride are pale green or white, with a vitreous lustre and high hardness. Boracite occurs in salt deposits.

translucent, prismatic crystals

COLEMANITE
Monoclinic • H 4½ • SG 2.42
This hydrated calcium borate hydroxide forms when saline water evaporates. It was the main source of boron until the discovery of kernite.

ULEXITE
Triclinic • H 2½ • SG 1.95
A hydrated sodium calcium borate hydroxide, ulexite's white, fibrous crystals transmit light down their length. It has uses similar to borax.

BORAX
Monoclinic • H 2–2½ • SG 1.71
A chalky-white sodium borate hydrate, borax has many applications, including in medicines, washing powders, glasses, and textiles.

HOWLITE
Monoclinic • H 3½–6½ • SG 2.6
Howlite is a calcium borosilicate hydroxide. It generally forms as chalky, rounded masses.

NITRATES

Nitrates are a small group of compounds where metallic elements combine with the nitrate radical (NO_3). These minerals are usually very soft and have low specific gravity. Many dissolve readily in water and they only rarely occur as crystals. They are generally confined to arid regions, forming coatings on the land surface that often cover wide areas. Commercially, nitrates can be used as fertilizers or explosives.

NITRATINE
Trigonal • H 1½–2 • SG 2.26
This sodium nitrate typically occurs as crusts on the ground surface in arid regions, especially in Chile. It is white, grey, brown, or yellow.

SULFATES

Sulfates are composed of metals combined with the sulfate radical (SO_4). There are about 200 sulfates and many are rare. Some, such as gypsum, form in evaporite deposits where minerals are precipitated from drying saline solutions. Others occur as weathering products, or as primary minerals in hydrothermal veins. Many are economically important – barite is used to lubricate drills on oil rigs.

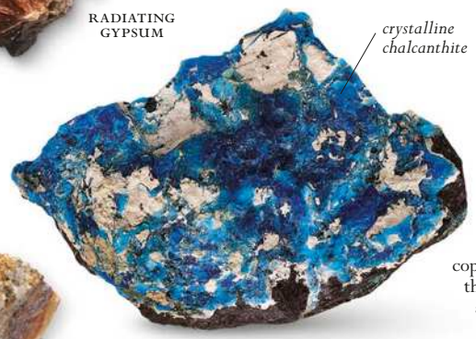
GYPSUM
Monoclinic • H 2 • SG 2.31–2.32
A widespread mineral, gypsum, a hydrated calcium sulfate, produces plaster of Paris when heated and mixed with water.

SATIN SPAR

THENARDITE
Orthorhombic
H 2½–3 • SG 2.66
A pale grey or brownish mineral, thenardite is a sodium sulfate. It is found on lava flows and around salt lakes.

RADIATING GYPSUM

crystalline chalcanthite



CHALCANTHITE
Triclinic
H 2½ • SG 2.29
Rich blue or green chalcanthite is a hydrated copper sulfate. It forms through the oxidation of chalcopyrite and other copper sulfates.

prismatic crystal

galena

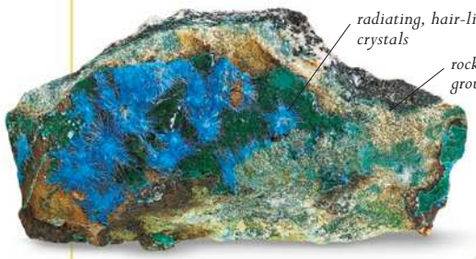
ANGLESITE
Orthorhombic
H 2½–3 • SG 6.32–6.39
This lead sulfate occurs in a variety of colours and forms. It is an alteration product of galena, the primary lead ore.

LINARITE
Monoclinic
H 2½ • SG 5.35
Bright blue linarite is a hydrous copper lead sulfate. It occurs in the oxidation zones of copper and lead ores.

mass of needle-shaped brochantite crystals

radiating, hair-like crystals

rock groundmass



CYANOTRICHITE
Monoclinic • H 1–3 • SG 2.76
This hydrated copper aluminium sulfate is named after the Greek for "blue" and "hair", referring to its clusters of fine, blue crystals.

GLAUBERITE
Monoclinic
H 2½–3 • SG 2.75–2.85
Glauberite is a sodium and calcium sulfate. Colourless, grey, or yellowish, it forms where saline water evaporates.

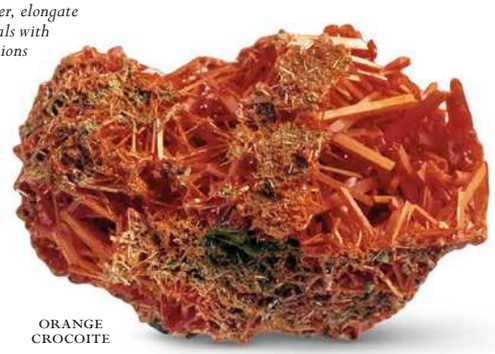
ALUNITE
Trigonal
H 3½–4 • SG 2.6–2.9
A hydrous sulfate of potassium and aluminium, alunite may be found at volcanic vents where rocks are altered by sulfur vapours.

CHROMATES

Chromate minerals form when metallic elements combine with the chromate radical (CrO_4). They are rare minerals – crocoite is the only reasonably well-known chromate. Generally brightly coloured, they are sought after by mineral collectors. Chromates often form when hydrothermal veins are altered by fluids.

RED CROCOITE

slender, elongate crystals with striations



ORANGE CROCOITE

CROCOITE
Monoclinic • H 2½–3 • SG 5.97–6.02
Orange or red lead chromate forms in the oxidized zones of lead deposits. Good specimens come from Australia.

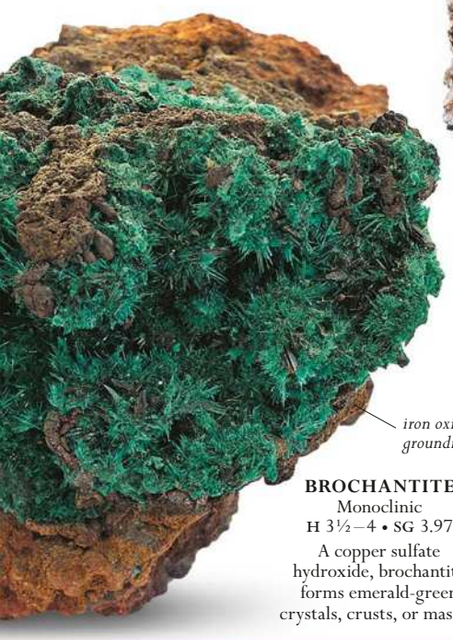
MELANTERITE
Monoclinic
H 2 • SG 1.89
White, green, or blue melanterite is hydrated iron sulfate. It is used in purifying water supplies, and as a fertilizer.

JAROSITE
Trigonal
H 2½–3½ • SG 2.9–3.26
Jarosite is a hydrous sulfate of iron and potassium, occurring as brown coatings on pyrite and other iron minerals.

CELESTINE
Orthorhombic • H 3–3½ • SG 3.96–3.98
This strontium sulfate is sought after, not only as the main source of strontium, but also for the beautiful, transparent, pale-coloured crystals.

EPSOMITE
Orthorhombic
H 2–2½ • SG 1.68
This hydrated magnesium sulfate occurs in arid regions and limestone cave walls. It is the source of the laxative Epsom salts.

COPIAPITE
Triclinic • H 2½–3 • SG 2.08–2.17
A yellow or green hydrated sulfate of iron first described from Copiapó, Chile, copiapite occurs where other minerals are altered.



BROCHANTITE
Monoclinic
H 3½–4 • SG 3.97
A copper sulfate hydroxide, brochantite forms emerald-green crystals, crusts, or masses.

ANHYDRITE
Orthorhombic
H 3–3½ • SG 2.98
A form of calcium sulfate, anhydrite occurs with gypsum but is less common. It alters to gypsum in humid conditions.

BARITE
Orthorhombic
H 3 • SG 4.5
The most common barium mineral, barium sulfate is unusually heavy for a pale-coloured mineral.

POLYHALITE
Triclinic • H 2½–3½ • SG 2.78
Polyhalite is a hydrated potassium calcium magnesium sulfate. Colourless, white, pink, or red, it is widespread in many marine salt deposits.

MOLYBDATES

Molybdates form when metals combine with the molybdate radical (MoO_4). These minerals are rare and tend to be dense and brightly coloured. Molybdate minerals occur in mineral veins that have been altered by circulating water. Wulfenite is the best-known molybdate mineral. It is prized for its fine crystals and brilliant orange or yellow colours.

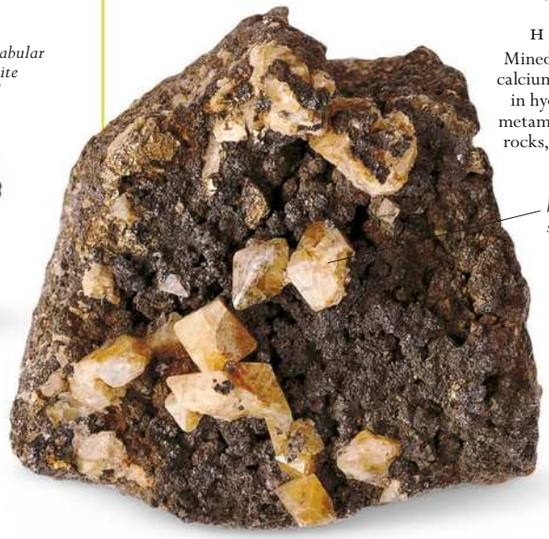
WULFENITE
Tetragonal • H 2½–3 • SG 6.5–7.5
This lead molybdate is found in oxidized zones of lead and molybdenum deposits. It is a minor source of molybdenum.

TUNGSTATES

Tungstate minerals are compounds with metallic elements joined to the tungstate radical (WO_4). These minerals are rare and usually have a high specific gravity. Some form as fine crystals. Tungstates occur in hydrothermal veins and pegmatites – very coarse-grained granitic rocks where minerals form from fluids permeating the rock.

HÜBNERITE
Monoclinic
H 4–4½ • SG 7.12–7.18
This manganese tungstate is a major source of tungsten, a metal used in steel alloys, abrasives, and light bulbs.

SCHEELITE
Tetragonal
H 4½–5 • SG 6.1
Mined for tungsten, this calcium tungstate is found in hydrothermal veins, metamorphic and igneous rocks, and alluvial sands.



FERBERITE
Monoclinic
H 4–4½ • SG 7.58
Opaque black ferberite is found in hydrothermal veins and granitic pegmatites. It is an iron tungstate, mined as a source of tungsten.

PHOSPHATES

When metals combine with the phosphate radical (PO_4), phosphate minerals are produced. These minerals form a large group of over 200 – however, many are very rare. Some minerals in this group are brightly coloured. They usually form by the alteration of sulfide minerals, but they are sometimes primary minerals. A number of phosphates are radioactive.

TURQUOISE
Triclinic • H 5–6 • SG 2.6–2.8
A sought after gem for thousands of years, this hydrated phosphate of copper and aluminium is found in altered igneous rocks.

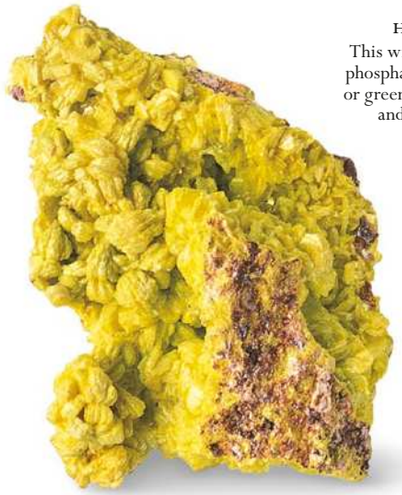
HYDROXYLHERDERITE
Monoclinic • H 5–5½ • SG 2.95
Hydroxylherderite is a calcium beryllium phosphate. It occurs as pale yellow or greenish crystals, with a glassy lustre, in granitic pegmatites.

PYROMORPHITE
Hexagonal • H 3½–4 • SG 7.04
A lead phosphate chloride, variably coloured greenish, orange, yellowish or brownish, pyromorphite forms in the oxidized zones of lead deposits.

DUFRÉNITE
Monoclinic
H 3½–4½ • SG 3.10–3.34
This hydrated phosphate of iron and calcium mainly occurs as green to black masses or crusts in altered veins and iron ores.

XENOTIME-(Y)
Tetragonal
H 4–5 • SG 4.4–5.1
This widely distributed yttrium phosphate is yellow-brown, grey, or greenish, and forms in igneous and metamorphic rocks.

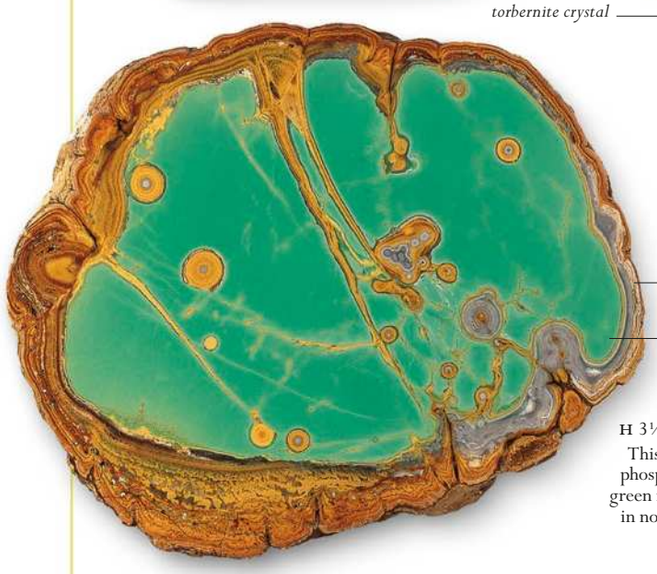
APATITE
Hexagonal
H 5 • SG 3.16–3.22
Apatite is the group name used for three similar calcium phosphate minerals: fluorapatite, chlorapatite, and hydroxylapatite.



AUTUNITE
Orthorhombic
H 2–2½ • SG 3.05–3.2
Radioactive autunite is a lemon-yellow or pale green hydrated phosphate of calcium and uranium. It occurs where uranium minerals are altered.

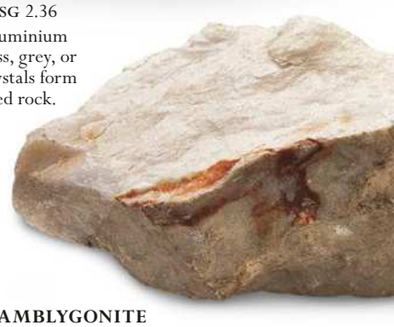
TORBERNITE
Tetragonal • H 2–2½ • SG 3.22
This copper uranium phosphate hydrate is related to autunite and occurs in similar geological environments. It is a radioactive mineral.

WAVELLITE
Orthorhombic • H 3½–4 • SG 2.36
Wavellite is a rare hydrated aluminium phosphate hydroxide. Colourless, grey, or greenish, glassy, needle-like crystals form radiating aggregates in altered rock.



VARISCITE
Orthorhombic
H 3½–4½ • SG 2.56–2.61
This hydrated aluminium phosphate usually occurs as green microcrystalline masses in nodules, veins, or crusts.

TRIPLITE
Monoclinic • H 5–5½ • SG 3.5–3.9
Triplite is a phosphate of manganese and fluorine, sometimes with iron. It forms in granitic pegmatites.



AMBLYGONITE
Triclinic • H 5½–6 • SG 3.04–3.11
This rare lithium aluminium fluorophosphate mainly forms as masses, but crystals occur in Zimbabwe and Brazil.

VIVIANITE
Monoclinic • H 1½–2 • SG 2.67–2.69
Vivianite is a hydrated iron phosphate. It commonly forms as clusters of dark prismatic crystals in altered iron deposits.

radiating acicular (needle-shaped) crystals

libethenite crystal

LIBETHENITE
Orthorhombic
H 4 • SG 3.97
Libethenite is a light to dark green copper phosphate hydroxide. It forms in the upper oxidized zone of copper deposits.

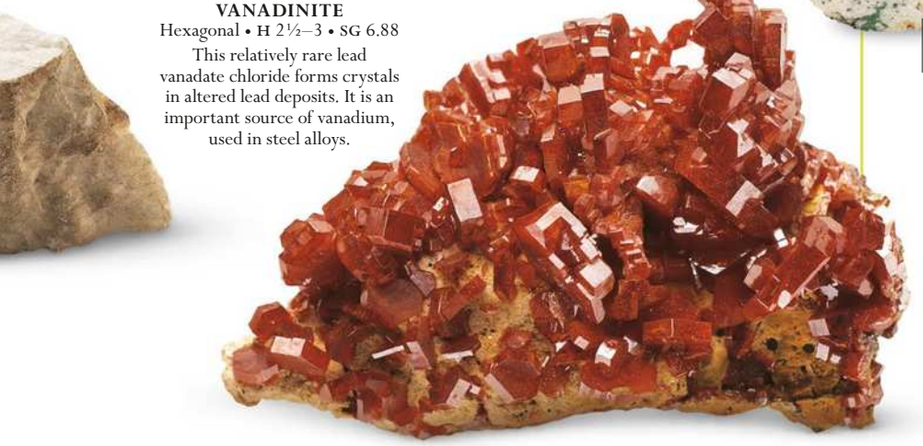
MONAZITE
Monoclinic • H 5–5½ • SG 5–5.5
Phosphate minerals containing either cerium, lanthanum, or neodymium are all referred to as monazite. They are mined for the various elements.

BRAZILIANITE
Monoclinic • H 5½ • SG 2.98
First discovered in Brazil, this sodium aluminium phosphate hydroxide is yellow or greenish and forms in cavities in granitic pegmatites.

bipyramidal crystal

LAZULITE
Monoclinic
H 5½–6 • SG 3.12–3.24
A relatively rare, semi-precious blue gemstone, this magnesium aluminium phosphate hydroxide occurs in metamorphic and igneous rocks.

VANADINITE
Hexagonal • H 2½–3 • SG 6.88
This relatively rare lead vanadate chloride forms crystals in altered lead deposits. It is an important source of vanadium, used in steel alloys.



VANADATES

Vanadates are formed by the combination of metallic elements and the vanadate radical (VO_4). This group contains many rare minerals, which may be dense and brightly coloured. Vanadates often form when hydrothermal veins are altered by permeating fluids. Most vanadates have no commercial value; however, carnotite is an important source of uranium.

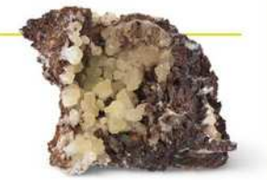
powdery crust on sandstone

CARNOTITE
Monoclinic • H 2 • SG 4.75
Generally occurring as powdery yellow crusts in uranium deposits, radioactive carnotite is a hydrated vanadate of potassium and uranium.

TYUYAMUNITE
Orthorhombic
H 1½–2 • SG 3.57–4.35
This rare hydrated vanadate of calcium and uranium looks similar to carnotite, and also occurs in altered uranium deposits.

ARSENATES

Arsenates are mostly rare minerals composed of metallic elements and the arsenate radical (AsO_3 or AsO_4). They generally have a low hardness. Many arsenates are brightly coloured – adamite is yellow or green, and clinoclase is green or blue. This group of minerals form in a variety of geological situations, but many arsenates occur in altered metal deposits.

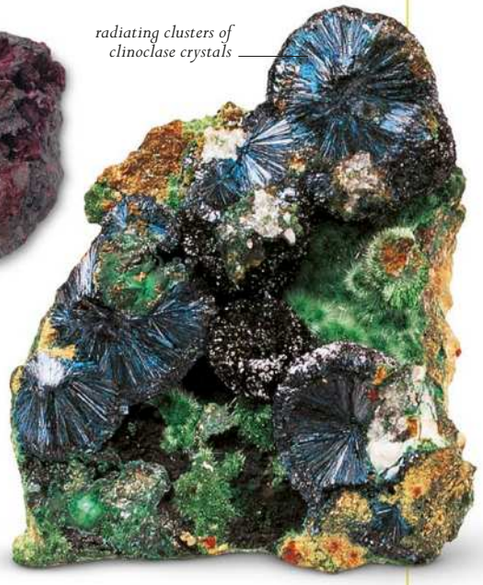


ADAMITE
Orthorhombic
H 3½ • SG 4.32–4.48
This zinc arsenate hydroxide occurs in altered arsenic and zinc deposits, sometimes as exceptional crystals.

ERYTHRITE
Monoclinic • H 1½–2½ • SG 3.06
This hydrated cobalt arsenate forms purple-pink crystals or coatings. Excellent examples occur in Canada and Morocco.

BAYLDONITE
Monoclinic
H 4½ • SG 5.24–5.65
This hydrous arsenate of copper and lead is usually found as green or yellow crusts in altered hydrothermal veins.

radiating clusters of clinoclase crystals



CLINOCLASE
Monoclinic • H 2½–3 • SG 4.38
Clinoclase is a dark blue-green copper arsenate hydroxide that has a variety of forms in altered copper sulfide deposits.

olivenite crystals

OLIVENITE
Monoclinic
H 3 • SG 4.46
Olivenite is a copper arsenate hydroxide. It can be greenish, brownish, yellow, or grey and occurs in altered copper deposits.

quartz

MIMETITE
Hexagonal • H 3½–4 • SG 7.24
Unusual, barrel-shaped crystals characterize this lead arsenate chloride, although other forms also exist. Mimetite occurs in altered lead deposits.

CHALCOPHYLLITE
Trigonal • H 2 • SG 2.67–2.69
Bright blue-green chalcophyllite is a hydrated copper aluminium arsenate sulfate. It forms in oxidized copper deposits.

SILICATES

Silicates are the most common and largest group of minerals. The fundamental building blocks are tetrahedra of silicon and oxygen (SiO_4) together with other elements. They are subdivided into six groups based on the arrangement of the silica tetrahedra. Some form as isolated tetrahedra (nesosilicates), others occur in pairs (sorosilicates), and yet others have a three-dimensional network of tetrahedra (tectosilicates). Some silicates occur as chains of tetrahedra (inosilicates), while others form as sheets (phyllosilicates) or rings (cyclosilicates).

NESOSILICATES

ANDRADITE
Cubic • H 6½–7 • SG 3.8–3.9
Yellowish green, brown, or black, andradite garnet is a calcium iron silicate. Cut gems are excellent at separating white light into colours.

MASSIVE DUMORTIERITE

DUMORTIERITE
Orthorhombic • H 7–8 • SG 3.21–3.41
Dumortierite is a silicate of aluminium, iron, and boron. It usually forms fibrous aggregates of radiating crystals, but it can also be massive.

EUCLASE
Monoclinic
H 7½ • SG 2.99–3.1
Euclase is a beryllium aluminium silicate hydroxide. It may form white, colourless, green, or blue prismatic, striated crystals.

HUMITE
Orthorhombic • H 6 • SG 3.2–3.32
A magnesium iron silicate fluorohydroxide, humite generally occurs as yellow to orange granular masses in metamorphosed limestones and dolomites.

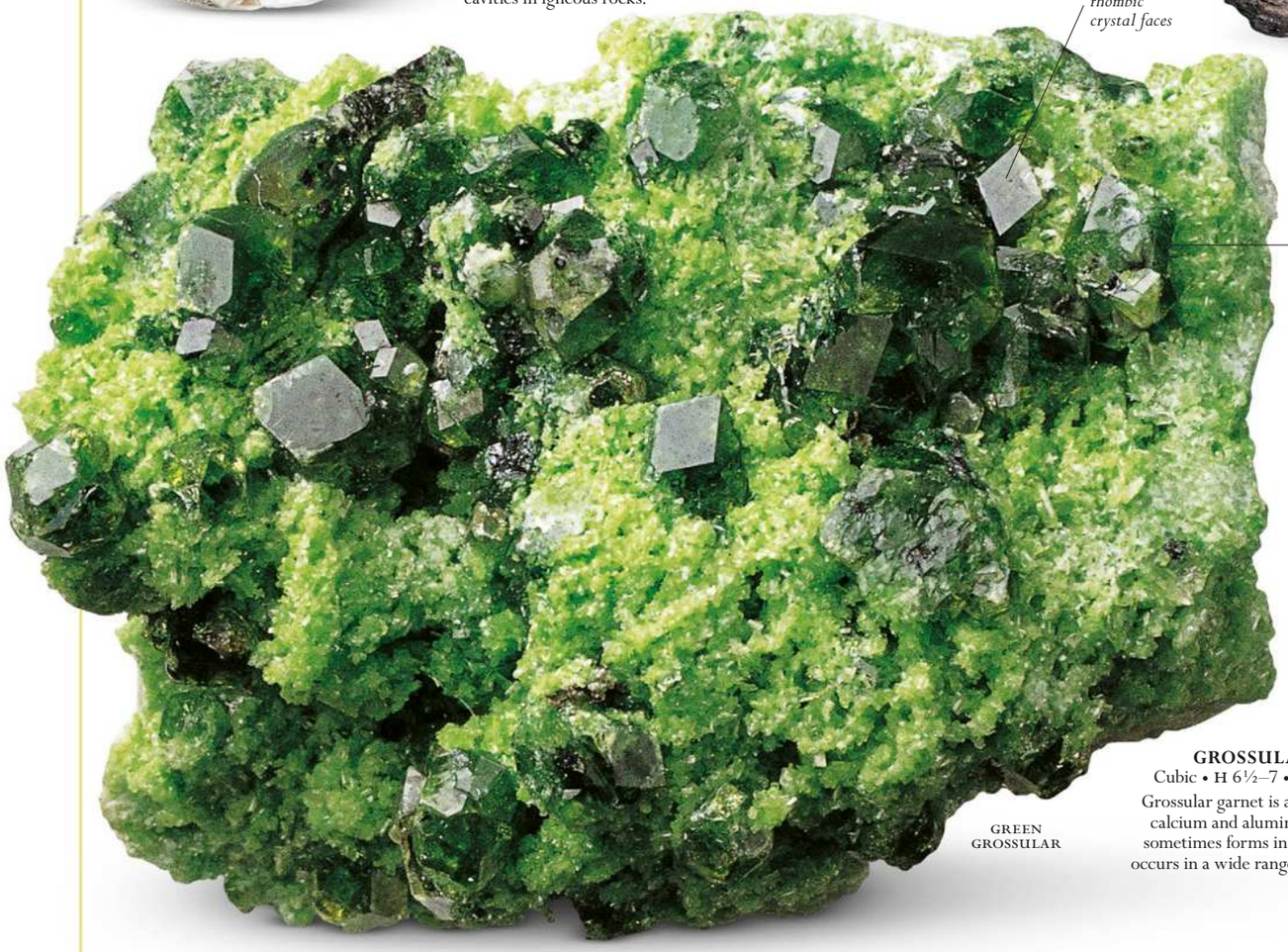
NORBERGITE
Orthorhombic
H 6–6½ • SG 3.18
Norbergite mainly occurs as brownish yellow, white, or pink granular masses in metamorphic rocks. It is a magnesium silicate fluorohydroxide.

KYANITE
Triclinic • H 5½–7 • SG 3.53–3.67
Kyanite is an aluminium silicate. Its bladed crystals in schist and gneiss formed at high pressures in the Earth.

DATOLITE
Monoclinic
H 5–5½ • SG 2.96–3
Datolite is a hydrous calcium boron silicate. Not very common, it is mainly found in veins or cavities in igneous rocks.

PYROPE
Cubic • H 7–7½ • SG 3.58
Pyrope garnet is a dark red magnesium aluminium silicate. It forms at high pressures in metamorphic and some igneous rocks.

ALMANDINE
Cubic • H 7–7½ • SG 4.32
The most common garnet, pinkish red almandine is an iron aluminium silicate. It is widely used as a gem.



GREEN GROSSULAR

GROSSULAR
Cubic • H 6½–7 • SG 3.59
Grossular garnet is a silicate of calcium and aluminium that sometimes forms in marble. It occurs in a wide range of colours.

RED GROSSULAR

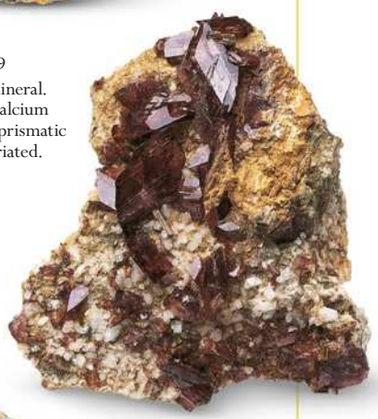
SOROSILICATES

OLIVINE
Orthorhombic
H 7 • SG 3.27–4.39
Common in igneous rocks, nesosilicate minerals varying in composition from magnesium silicate to iron silicate are called olivine.

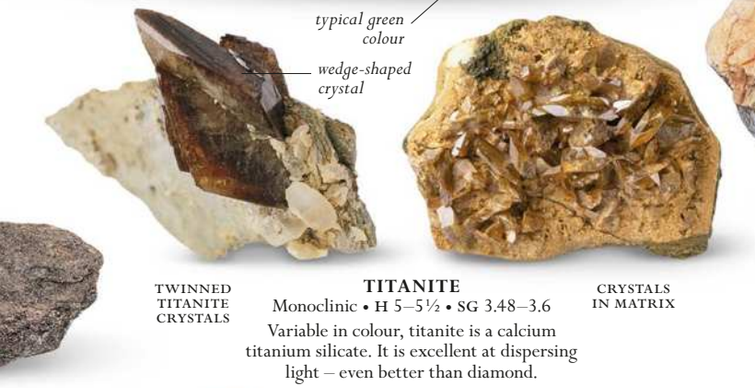
TOPAZ
Orthorhombic • H 8 • SG 3.4–3.6
Topaz is an aluminium silicate fluoride hydroxide. Crystal size is usually small, but a giant crystal weighing 271 kg (596 lb) is known from Brazil.

EPIDOTE
Monoclinic
H 6 • SG 3.38–3.49
Epidote is an abundant mineral. Crystals of this hydrous calcium aluminium iron silicate are prismatic or tabular, green, and striated.

AXINITE
Triclinic
H 6½–7 • SG 3.25–3.28
Axinite is a hydrous calcium iron manganese aluminium boron silicate, with axe-head-shaped crystals.



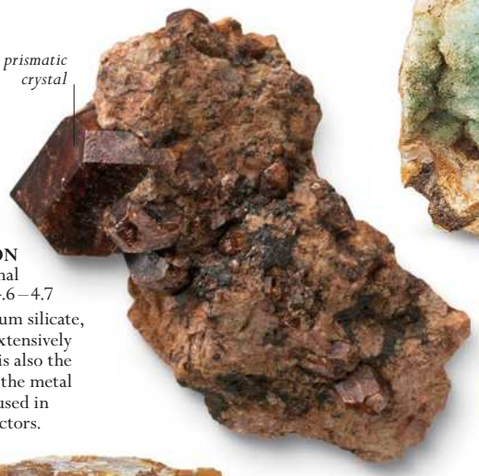
CHLORITOID
Monoclinic • H 6½ • SG 3.4–3.8
Widespread in metamorphic and volcanic rocks, chloritoid is a dark green or black hydrous aluminium silicate of iron, magnesium, and manganese.



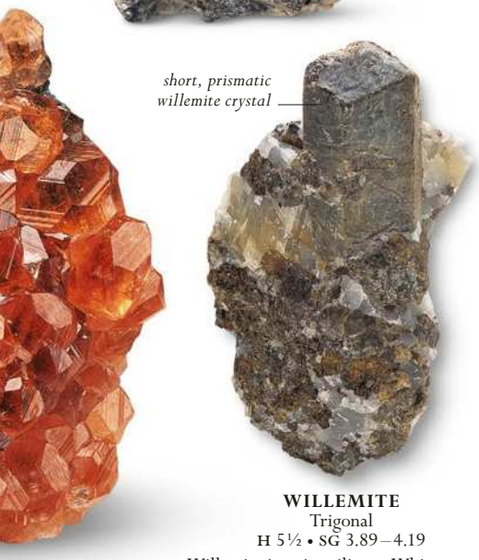
TITANITE
Monoclinic • H 5–5½ • SG 3.48–3.6
Variable in colour, titanite is a calcium titanium silicate. It is excellent at dispersing light – even better than diamond.

HEMIMORPHITE
Orthorhombic
H 4½–5 • SG 3.48
This hydrated silicate of zinc occurs in altered zinc deposits. It is very variable in both its colour and form.

ANDALUSITE
Orthorhombic
H 6½–7½ • SG 3.13–3.21
Andalusite is an aluminium silicate. It occurs mainly in low-grade metamorphic rocks as coarse prismatic crystals with a square cross-section.



ZIRCON
Tetragonal
H 7½ • SG 4.6–4.7
Zircon, a zirconium silicate, is a gem used extensively in jewellery. It is also the main source of the metal zirconium, used in nuclear reactors.



WILLEMITE
Trigonal
H 5½ • SG 3.89–4.19
Willemite is a zinc silicate. White, green, yellow, or reddish, and usually massive, it occurs in altered zinc deposits and metamorphosed limestone.

SILLIMANITE
Orthorhombic • H 6½–7½ • SG 3.23–3.27
Sillimanite is an aluminium silicate with long, slender crystals. Its composition is identical to that of andalusite, but it forms at higher temperatures and pressures.

DANBURITE
Orthorhombic
H 7–7½ • SG 2.93–3.02
Danburite is a calcium boron silicate. Its variably coloured crystals resemble those of topaz, but it can also be granular.

VESUVIANITE
Tetragonal
H 6½ • SG 3.32–3.43
Vesuvianite, also known as idocrase, is a hydrous calcium sodium magnesium iron aluminium silicate, with fluorine. It occurs in marble and igneous rocks.

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CYCLOSILICATES

BENITOITE
Hexagonal
H 6–6½ • SG 3.64–3.65
This usually blue barium titanium silicate occurs in serpentinite and veins in schist. Gem-quality crystals come from California, USA.

TOURMALINE
Trigonal
H 7 • SG 2.9–3.1
Tourmaline is the name for a group of 11 hydrous boron silicate minerals with the same crystal structure but varying chemistry.

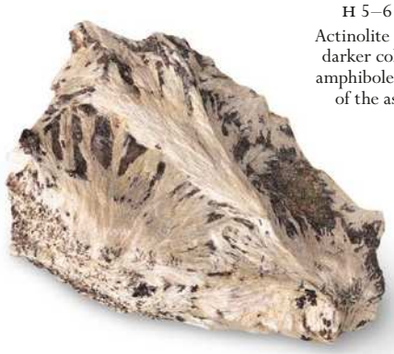
BERYL
Hexagonal
H 7½–8 • SG 2.63–2.92
This beryllium aluminium silicate is both a source of beryllium and a gemstone. Gem varieties include emerald (green) and aquamarine (greenish blue).

MORGANITE
Hexagonal
H 7½–8 • SG 2.63–2.92
Morganite is a pink variety of beryl, coloured by additional cesium or manganese. It forms tabular crystals in pegmatites.

SUGILITE
Hexagonal
H 6–6½ • SG 2.74–2.79
This rare silicate of potassium, sodium, iron, and lithium occurs in metamorphic rock.

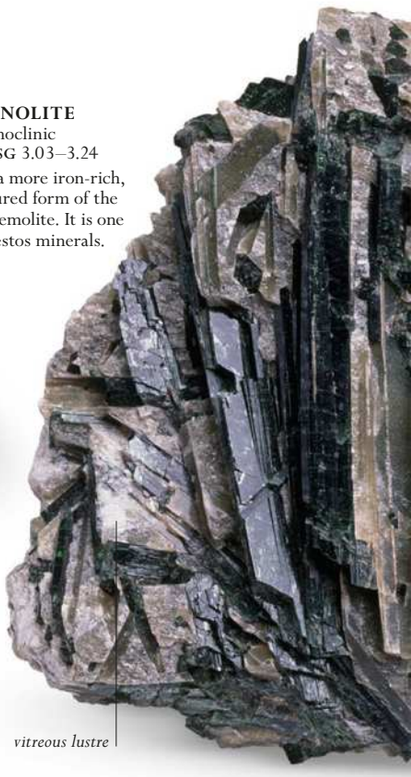
HELIODOR
Hexagonal
H 7½–8 • SG 2.63–2.92
Named after the Greek for "sun", heliodor is a yellow variety of beryl. Fine examples come from Russia.

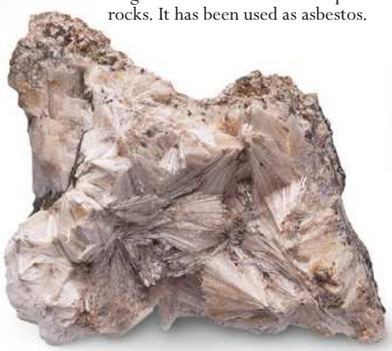
INOSILICATES



ACTINOLITE
Monoclinic
H 5–6 • SG 3.03–3.24
Actinolite is a more iron-rich, darker coloured form of the amphibole tremolite. It is one of the asbestos minerals.

TREMOLITE
Monoclinic • H 5–6 • SG 2.99–3.03
A widespread amphibole, this hydrous silicate of calcium and magnesium forms in metamorphic rocks. It has been used as asbestos.



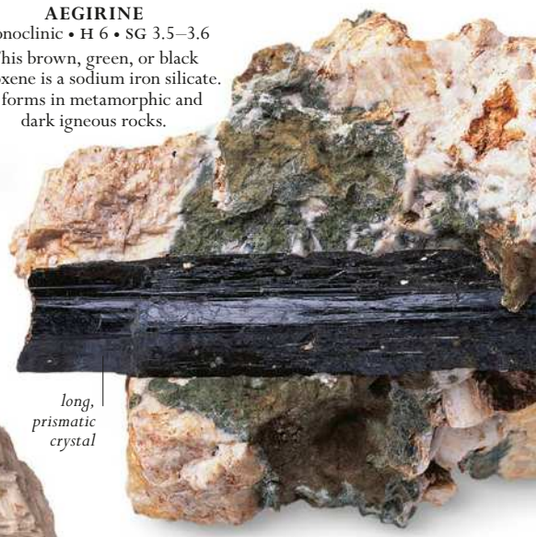


PECTOLITE
Triclinic • H 4½–5 • SG 2.48–2.9
This sodium calcium silicate hydroxide forms in cavities within basalt. It is common in Canada, the USA, and England.

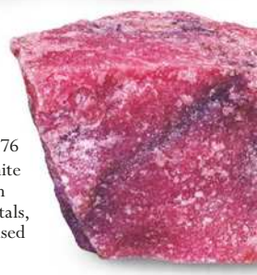
NEPHRITE
Monoclinic • H 6½ • SG 2.99–3.24
This very tough, cream to dark green form of the amphiboles tremolite and actinolite is commonly known as jade.

HORNBLENDE
Monoclinic • H 5–6 • SG 3–3.4
Common in igneous and metamorphic rocks, this amphibole mineral is a dark, hydrous silicate of calcium, magnesium, iron, and aluminium.

AEGIRINE
Monoclinic • H 6 • SG 3.5–3.6
This brown, green, or black pyroxene is a sodium iron silicate. It forms in metamorphic and dark igneous rocks.



WOLLASTONITE
Triclinic • H 4½–5 • SG 2.86–3.09
This calcium silicate, found in marble and other metamorphic rocks, is used in ceramics, paints, and as a form of asbestos.



RHODONITE
Triclinic
H 5½–6½ • SG 3.57–3.76
Rose-red or pink rhodonite is a manganese calcium silicate, occurring as crystals, masses, and grains. It is used in jewellery making.

SPODUMENE
Monoclinic • H 6½–7 • SG 3.1–3.2
This pyroxene mineral is a lithium aluminium silicate. Some enormous crystals have been found; the largest weighed almost 100 tonnes.

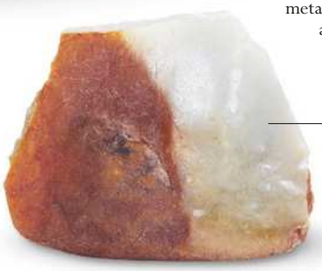
DIOPSIDE
Monoclinic • H 5½–6½ • SG 3.22–3.38
This pyroxene is a generally green-coloured calcium magnesium silicate. It occurs in metamorphic and igneous rocks.

RICHTERITE
Monoclinic
H 5–6 • SG 3.1
The amphibole richterite is a hydrous silicate of sodium, calcium, and magnesium. It occurs in metamorphosed limestones and igneous rocks.

PIGEONITE
Monoclinic
H 6 • SG 3.3–3.46
This brown to purplish black uncommon pyroxene is a magnesium iron calcium silicate. It occurs in igneous rocks and in meteorites.

AUGITE
Monoclinic
H 5½–6 • SG 3.19–3.56
Augite is a common pyroxene. This silicate of calcium, magnesium, and iron occurs in igneous and metamorphic rocks.

ASTROPHYLLITE
Triclinic • H 3 • SG 3.2–3.4
This complex hydrous silicate of potassium, sodium, iron, and titanium, with fluorine, occurs in gneiss and cavities in igneous rocks.



JADEITE
Monoclinic
H 6 • SG 3.25–3.35
One of two carvable materials commonly referred to as jade, this pyroxene mineral is a sodium aluminium iron silicate.

RIEBECKITE
Monoclinic • H 5–5½ • SG 3.26–3.44
This amphibole is a hydrous sodium iron silicate, occurring in igneous rocks. The variety crocidolite, or "blue asbestos", occurs in metamorphosed ironstone.

»

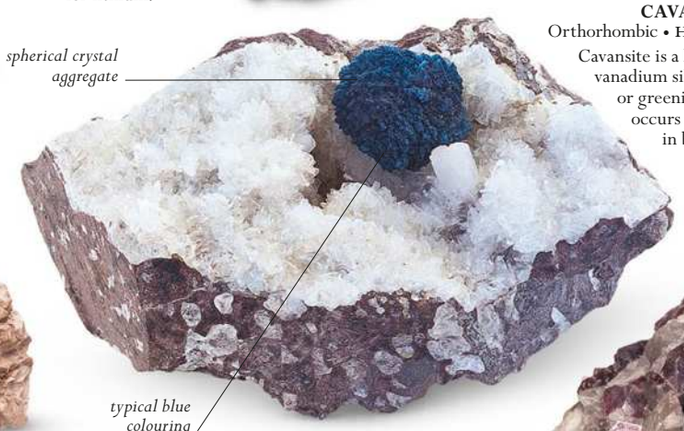
PHYLLOSILICATES

PREHNITE
Orthorhombic
H 6–6½ • SG 2.8–2.95
Prehnite is a hydrous silicate of calcium and aluminium. It occurs in cavities in basalt.

OKENITE
Triclinic • H 4½–5 • SG 2.28–2.33
This hydrated calcium silicate has fibrous or blade-like crystals, usually white or tinted blue or yellow. It occurs in basalt.

PHLOGOPITE
Monoclinic
H 2–3 • SG 2.78–2.85
The colourless, yellow, or brown mica phlogopite is a potassium magnesium aluminosilicate hydroxide.

PETALITE
Monoclinic
H 6½ • SG 2.41–2.42
Petalite is a lithium aluminium silicate. Crystals are usually grey-white and in aggregates. It is mined for lithium.



CAVANSITE
Orthorhombic • H 3–4 • SG 2.21–2.31
Cavansite is a hydrated calcium vanadium silicate. It is blue or greenish blue, and occurs in cavities in basalt.

SEPIOLITE
Orthorhombic • H 2 • SG 2–2.2
This pale-coloured clay mineral, a hydrous magnesium silicate, usually occurs as earthy masses in altered rocks. It is used for ornamental carving.

LEPIDOLITE
Monoclinic • H 2½–3½ • SG 2.80–2.9
Lepidolite is the term used for mica minerals that are potassium lithium aluminium aluminosilicate hydroxides, with fluorine.

CLINOCHLORE
Monoclinic
H 2–2½ • SG 2.6–3.02
This hydrous silicate of iron, magnesium, and aluminium forms as green tabular crystals. It occurs in a variety of rock types.

MUSCOVITE
Monoclinic
H 2½ • SG 2.77–2.88
Muscovite, or white mica, is a potassium aluminium aluminosilicate hydroxide, with fluorine. It is very common in metamorphic rocks and granite.

TECTOSILICATES

SMOKY QUARTZ
Trigonal • H 7 • SG 2.65
Smoky quartz is a brown variety of quartz, a silicon dioxide. It occurs in igneous rocks and hydrothermal veins.

ROSE QUARTZ
Trigonal • H 7 • SG 2.65
Rose quartz is a prized, translucent pink variety of quartz. Crystals are very rare; it usually has a massive habit.

MILKY QUARTZ
Trigonal
H 7 • SG 2.65
This very common, milky white variety of quartz occurs in all types of rocks and in hydrothermal veins.

CITRINE
Trigonal
H 7 • SG 2.65
Citrine is a yellow to brownish variety of quartz. It resembles topaz and is often used as a gemstone.

AMETHYST
Trigonal
H 7 • SG 2.65
Amethyst is a purple variety of quartz, prized since ancient times. It is found in hydrothermal veins and in lava cavities.

PYROPHYLLITE
Triclinic
H 1–2 • SG 2.65–2.9
This aluminium silicate hydroxide, of variable form and colour, occurs in low-grade metamorphic rocks. It has good insulating properties.

ZINNWALDITE
Monoclinic • H 3½–4
SG 2.9–3.1
This brown, grey, or green mica is potassium lithium iron aluminium aluminosilicate hydroxide, with fluorine.

CHRYSOCOLLA
Orthorhombic
H 2½–3½ • SG 1.93–2.4
This blue or greenish blue hydrated silicate of copper and aluminium forms in altered copper deposits. Crystals do not occur.

VERMICULITE
Monoclinic
H 1½ • SG 2.4–2.7
This green or yellow clay mineral often occurs where micas have been altered. It is a hydrated silicate of magnesium, iron, and aluminium.

GLAUCONITE
Monoclinic • H 2 • SG 2.4–2.95
A mica, glauconite is a potassium sodium magnesium aluminium iron aluminosilicate hydroxide. It occurs in marine sedimentary rocks.

CHRYSOTILE
Monoclinic • H 2½ • SG 2.53
Chrysotile is a hydrous silicate of magnesium, forming fibrous, silky, white crystals in serpentinite rock. It is the most abundant of the asbestos minerals.

BIOTITE
Monoclinic • H 2½–3 • SG 3.3
Biotite, or black mica, is a potassium iron magnesium aluminosilicate hydroxide, with fluorine. It is abundant in igneous and metamorphic rocks.

TALC
Triclinic
H 1 • SG 2.58–2.83
The softest mineral, white, grey, or greenish talc is magnesium silicate hydroxide. Its many uses include toiletries, paint, and ceramics.

ALLOPHANE
Amorphous
H 3 • SG 2.8
A clay mineral, this aluminosilicate hydrate is an alteration product of feldspars and other minerals. It forms crusty masses.

ROCK CRYSTAL
Trigonal
H 7 • SG 2.65
Rock crystal is a transparent, colourless variety of quartz, which is widely used as an ornament or a gemstone.

JASPER
Trigonal • H 7 • SG 2.6
Jasper is a variety of chalcedony, or microcrystalline quartz, and is used for jewellery. It is opaque, and usually coloured red by impurities.

AGATE
Trigonal
H 7 • SG 2.6
Forming in cavities in lavas, agate is a type of chalcedony. It is characterized by concentric colour bands caused by impurities.

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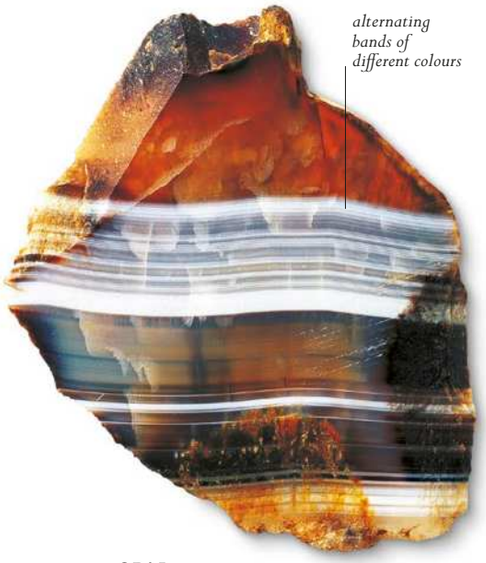
» TECTOSILICATES



OPAL
Amorphous
H 5½–6½ • SG 1.9–2.3
Opal is a hydrated silicon dioxide, occurring as nodules, encrustations, or masses in most rock types. Impurities impart a varietyof colours. Opal is treasured as a gemstone.

CHALCEDONY
Trigonal
H 7 • SG 2.65
Chalcedony is microcrystalline quartz, a silicon dioxide. Pure chalcedony is white. It forms in veins and cavities in many rock types.

ONYX
Trigonal
H 7 • SG 2.7
Onyx is a parallel-banded gemstone variety of chalcedony. It is not particularly common; notable locations are India and S. America.

CARNELIAN
Trigonal
H 7 • SG 2.7
Carnelian is a variety of chalcedony coloured red to orange by iron oxide. The finest quality carnelian comes from India.

BLOODSTONE
Trigonal • H 7 • SG 2.7
Bloodstone is a variety of chalcedony coloured dark green by traces of iron silicates. Flecks of red jasper throughout resemble blood.

CHRYSOPRASE
Trigonal • H 7 • SG 2.7
Chrysoprase is a variety of chalcedony containing nickel, which imparts a green colour. It is the most valuable of the chalcedony varieties.

CANCRINITE
Hexagonal
H 5–6 • SG 2.42–2.51
The feldspathoid cancrinite is a variously coloured hydrated sodium calcium aluminosilicate carbonate sulfate.

SCAPOLITE
Tetragonal
H 5½–6 • SG 2.5–2.78
The name scapolite encompasses a series of complex sodium calcium silicates, occurring mainly in metamorphic rocks.

MICROCLINE
Triclinic
H 6–6½ • SG 2.54–2.57
A very common alkali feldspar, this potassium aluminosilicate is usually white or pinkish. The green variety is called amazonstone.

ANORTHITE
Triclinic
H 6–6½ • SG 2.74–2.76
This plagioclase feldspar is a calcium aluminosilicate. It forms pale-coloured crystals, grains, or masses.

HEULANDITE
Monoclinic
H 3–3½ • SG 2.2
This zeolite is a hydrated sodium calcium aluminosilicate. It is used in petroleum refining as a molecular sieve.

SCOLECITE
Monoclinic
H 5–5½ • SG 2.25–2.29
This zeolite is a hydrated calcium aluminosilicate. Usually colourless or white, it is common in igneous and metamorphic rocks.

ANDESINE
Triclinic
H 6–6½ • SG 2.66–2.68
A plagioclase feldspar, andesine is a grey or white sodium calcium aluminosilicate. It is widespread in igneous rocks.

NATROLITE
Orthorhombic
H 5–5½ • SG 2.2–2.26
One of the most widespread zeolites, this hydrated sodium aluminosilicate occurs in cavities in basalts, and in hydrothermal veins.

HYALOPHANE
Monoclinic
H 6–6½ • SG 2.81
A relatively rare barium feldspar, this potassium barium aluminosilicate is colourless, white, yellow, or pink.

long, slender, needle-like crystals

massive sodalite

SODALITE
Cubic
H 5½–6 • SG 2.27–2.33
The feldspathoid mineral sodalite is a sodium aluminium silicate chloride. Rare crystals have been found in Canada.

STILBITE
Monoclinic
H 3½–4 • SG 2.19
This widespread zeolite is a hydrated sodium calcium potassium aluminosilicate. It forms sheaf-like crystals in a variety of rock types.

HARMOTOME
Monoclinic
H 4–5 • SG 2.41–2.47
This widespread zeolite is a pale hydrated barium calcium potassium sodium aluminosilicate. It occurs in hydrothermal veins and volcanic rocks.

ANALCIME
Triclinic
H 5–5½ • SG 2.24–2.29
This pale zeolite, a hydrated sodium aluminosilicate, occurs in igneous, metamorphic, and some sedimentary rocks.

ALBITE
Triclinic
H 6–6½ • SG 2.6–2.65
A plagioclase feldspar, albite is a pale-coloured sodium aluminosilicate. It is an abundant mineral.

ANORTHOCLASE
Triclinic
H 6–6½ • SG 2.57–2.6
An alkali feldspar, anorthoclase is a sodium potassium aluminosilicate occurring as prismatic or tabular crystals.

lazurite crystal

calcite

LAZURITE
Cubic
H 5–5½ • SG 2.38–2.45
The intense blue feldspathoid mineral lazurite is a sodium calcium aluminosilicate sulfate. It is the main mineral in lapis lazuli gems.

THOMSONITE
Orthorhombic
H 5–5½ • SG 2.23–2.29
A pale-coloured zeolite, thomsonite is a hydrated aluminosilicate of sodium and calcium, widespread in cavities in basalts.

POLLUCITE
Cubic
H 6½ • SG 2.9
A rare zeolite, this complex hydrated aluminosilicate of caesium and sodium commonly contains other elements, such as calcium. It is a source of caesium.

short, prismatic orthoclase crystal

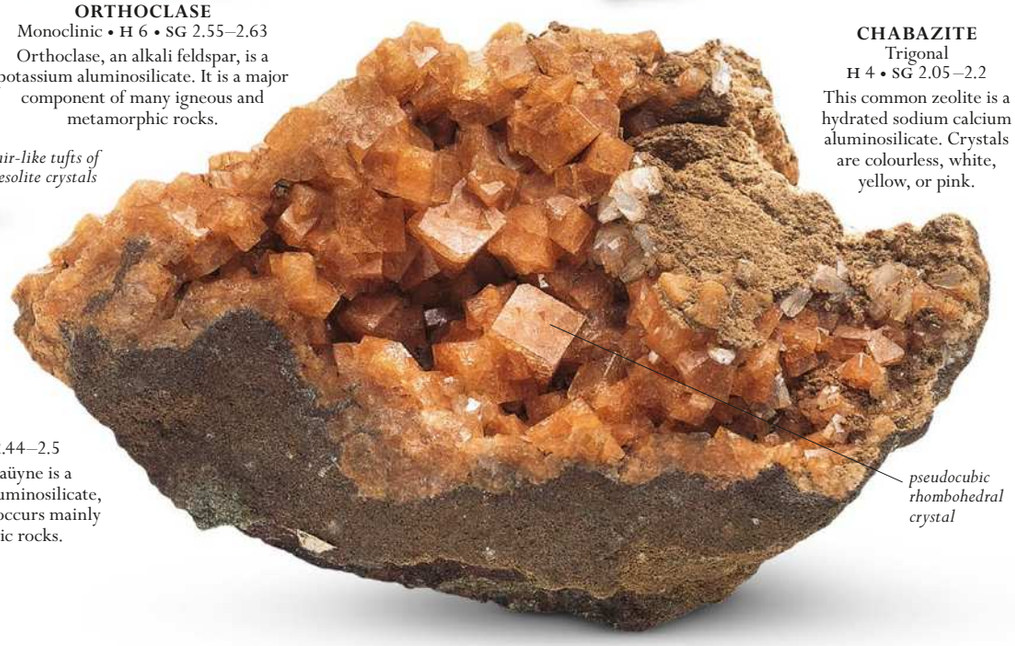
ORTHOCLASE
Monoclinic • H 6 • SG 2.55–2.63
Orthoclase, an alkali feldspar, is a potassium aluminosilicate. It is a major component of many igneous and metamorphic rocks.

LAUMONTITE
Monoclinic
H 3½–4 • SG 2.23–2.41
A widespread zeolite, laumontite is a hydrated calcium aluminosilicate. It occurs in igneous, metamorphic, and sedimentary rocks.

hair-like tufts of mesolite crystals

MESOLITE
Orthorhombic • H 5 • SG 2.26
This white or colourless zeolite occurs in igneous and metamorphic rocks. It is a hydrated sodium calcium aluminosilicate.

HAÜYNE
Cubic • H 5½–6 • SG 2.44–2.5
A feldspathoid mineral, haüyne is a sodium potassium calcium aluminosilicate, with sulfate and chlorine. It occurs mainly in silica-deficient volcanic rocks.



CHABAZITE
Trigonal
H 4 • SG 2.05–2.2
This common zeolite is a hydrated sodium calcium aluminosilicate. Crystals are colourless, white, yellow, or pink.

pseudocubic rhombohedral crystal

ROCKS

The rocks that form Earth's crust are composed of different combinations of minerals. Thought of as the epitome of strength and solidity, they are actually in a state of constant change, with rock being destroyed and reformed over immense periods of time. Rocks are classified into three main groups, depending on how they form.

Igneous rocks can be formed by the cooling of magma deep underground, like this granite, or by volcanic eruption.

Sedimentary rocks such as sandstone are formed by the erosion of existing rocks and the deposition of their fragments.

Metamorphic rocks such as schist form when changes in pressure, temperature, or both alter existing rocks.

The world's oldest known rocks, from Canada's Northwest Territories, have existed for about 4 billion years, but most rocks are far younger than this. The chalk cliffs facing the English Channel date back to the Cretaceous Period, which ended 66 million years ago (see timeline, below), and the European Alps are younger still. Even in the Grand Canyon, the oldest rocks date back 2 billion years – less than half the lifetime of the planet as a whole. The reason for this is that Earth is tectonically active, with new rock being formed by the planet's internal heat. At the same time, existing rocks are broken down, in an endless cycle that started when Earth's crust first solidified.

ROCK GROUPS

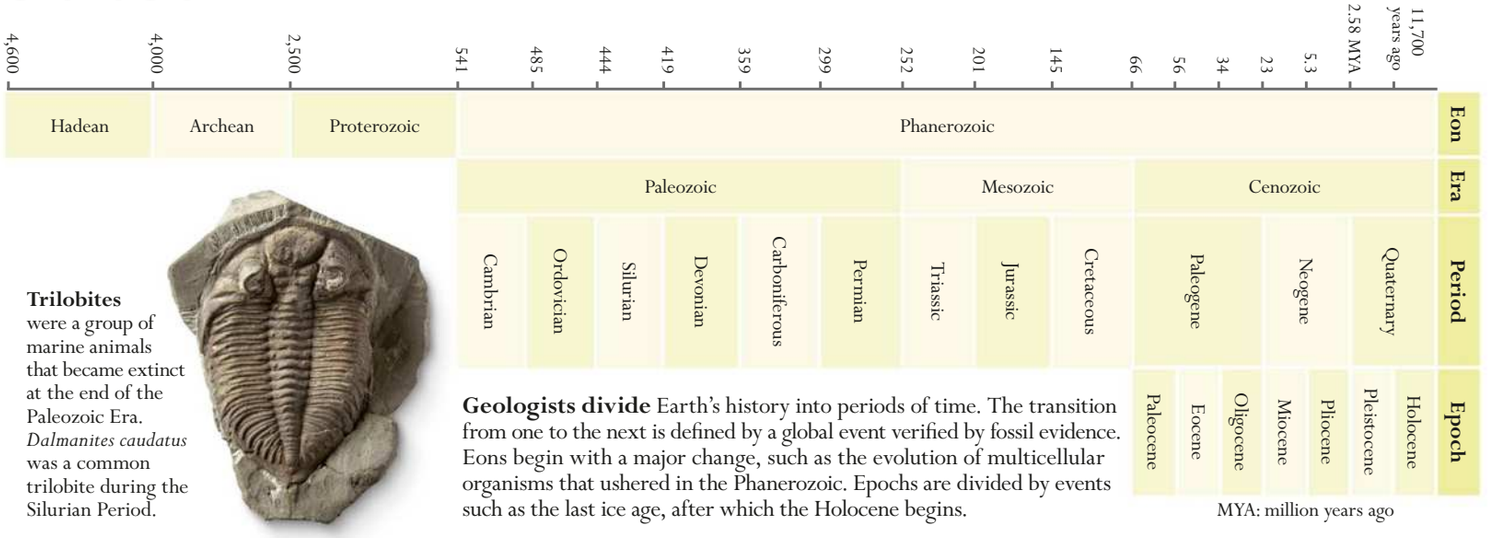
Geologists classify rocks into three overall groups – igneous, sedimentary, and metamorphic – reflecting the different ways in which they are formed. Igneous rocks are created by lava from volcanic eruptions on Earth's surface and from the cooling of molten magma underground. The heat in lava and magma rises from the mantle beneath Earth's crust. The commonest kind, a black volcanic rock called basalt forms most of the sea floor. Igneous activity can also create plutonic rock, which cools and solidifies beneath the surface, often in huge masses called batholiths. This is how most of the world's granite originates.

Sedimentary rocks are created on Earth's surface. Their key feature is their layers, or strata, built up over long periods of time. Some sedimentary rocks – such as sandstone and shale – form when existing rocks are eroded, releasing particles that are then washed or blown away, producing rock elsewhere. Others, such as rock salt and rock gypsum, are created when salt water evaporates, leaving behind its dissolved minerals, known as evaporites. Sedimentary rock can also have a biological origin: chalk is formed from the microscopic skeletons of marine organisms, and coal is derived from the remains of plants, compressed over millions of years.

Metamorphism takes place deep beneath Earth's surface, when rocks are altered by heat, pressure, or both. For example, marble is created when limestone is heated by lava or by magma. Recrystallization of the limestone may remove any bedding in the original rock, enabling some marbles to be cut without splitting apart, a quality prized in sculpture. Metamorphism can take place over very wide areas. If temperature and pressure are sufficiently high, all rocks can be metamorphosed and ultimately melted, forming magma and completing the rock cycle.

GRAND CANYON, USA >
This view of the Grand Canyon shows the almost horizontal layering of sedimentary rocks and the effects of river erosion.

GEOLOGICAL TIMELINE



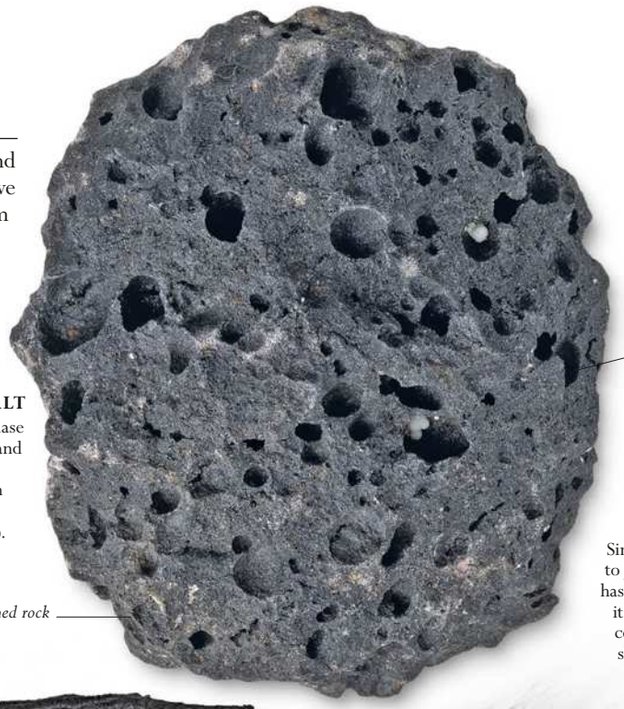
Geologists divide Earth's history into periods of time. The transition from one to the next is defined by a global event verified by fossil evidence. Eons begin with a major change, such as the evolution of multicellular organisms that ushered in the Phanerozoic. Epochs are divided by events such as the last ice age, after which the Holocene begins.

MYA: million years ago

Trilobites were a group of marine animals that became extinct at the end of the Paleozoic Era. *Dalmanites caudatus* was a common trilobite during the Silurian Period.

IGNEOUS ROCKS

Rocks that solidify from a molten state are called igneous rocks and are broadly divided into extrusive rocks and intrusive rocks. Extrusive rocks form from lava on Earth's surface, while intrusive rocks form underground, from magma. Lava and magma are rich in silica and metallic elements. As they cool, minerals such as feldspars, micas, amphiboles, and pyroxenes form. Different combinations of these minerals make up many of the igneous rocks.



RHYOLITE
This fine-grained, pale-coloured lava contains much quartz, mica, and feldspar. It frequently includes visible phenocrysts (larger crystals).

BANDED RHYOLITE
Similar in composition to granite, rhyolite also has tiny crystals because it forms from rapidly cooled lava. Banding shows the direction of lava flow.

BASALT
A dark, fine-grained volcanic rock, basalt is the most common rock forming the oceanic crust.

VESICULAR BASALT
Dominated by plagioclase feldspars, pyroxenes, and olivine, this lava is dark-coloured, with numerous vesicles (former gas cavities).

PAHOEHOE
Common in Hawaii, pahoehoe is named after the Hawaiian word *hoe*, meaning "to swirl". This basaltic lava is also known as ropy lava.

AMYGDALOIDAL BASALT
Amygdaloidal means almond-shaped and refers to the gas bubble cavities found in basaltic lavas, which are typically infilled with secondary minerals such as zeolites, carbonates, and agate.

PORPHYRITIC BASALT
This dark-coloured rock has large crystals, typically of olivine or plagioclase feldspars, set in a fine-grained matrix.

PÉLÉ'S HAIR
Named after a Hawaiian goddess, and composed of numerous slender, brown, glassy strands, Pélé's hair is formed by lava sprays being blown in the wind.

PUMICE
Formed from frothy lava, pumice contains small crystals of feldspar in a very fine-grained matrix. It is of such low density that it floats on water.

IGNIMBRITE
A very fine-grained, pale-coloured volcanic tuff, ignimbrite often shows banding caused by the flow of lava when molten.

LITHIC TUFF
This rock contains fragments of previously formed rock in a very fine-grained matrix. Usually pale, lithic tuff is formed by violent volcanic eruptions.

SPINDLE BOMB
Molten, low-viscosity basaltic lava blasted through the air can assume aerodynamic forms such as this one. These masses cool to form "bombs".

BREADCRUST BOMB
This variety of volcanic bomb is characterized by a cracked crust, due to continued expansion of the interior after the exterior has solidified.

AGGLOMERATE
Composed of relatively large rock fragments set in a finer matrix, agglomerate forms after volcanic explosions.

PITCHSTONE
This dense volcanic rock has variable composition and colour, and a pitch-like, resinous lustre.

PORPHYRITIC TRACHYTE
This rock has a complex mineralogy of alkali feldspars, quartz, micas, pyroxenes, and hornblende. Its fine-grained matrix contains larger crystals.

PORPHYRITIC ANDESITE
Commonly composed of plagioclase feldspars, pyroxenes, and amphiboles, porphyritic andesite contains larger crystals set in its fine-grained matrix.

ANDESITE
Named after the Andes mountains, andesite is common in many of the world's subduction-related volcanic arcs – chains of islands and mountains formed by tectonic plate movement. It is typically about 60 per cent silica.

DACITE
A pale- to medium-coloured rock with very fine grains, dacite is mainly made of plagioclase feldspars and quartz, with pyroxenes, biotite mica, and hornblende.

AMYGDALOIDAL ANDESITE
Brown, grey, purple, or red, this is a fine-grained volcanic rock containing infilled gas bubbles called amygdales.

SPILITE
This fine-grained, brownish volcanic rock contains augite and plagioclase feldspars. It forms by the alteration of basalt lava in contact with sea water.

TRACHYTE
Trachytes are a group of fine-grained volcanic rocks containing alkali feldspars and dark-coloured mafic minerals such as biotite, hornblende, and pyroxenes.

curved fracture

OBSIDIAN
Typically very dark, obsidian is formed by the rapid cooling of highly viscous rhyolitic lava before individual minerals have had time to form crystals. This gives it a glassy texture. Obsidian has been used as a cutting tool since ancient times.

pale patch of devitrified glass

SNOWFLAKE OBSIDIAN
The "snowflakes" in this glassy, black volcanic rock, with a high silica content, are areas of devitrified (crystalline) glass.

RHOMB PORPHYRY
This rock is characterized by large crystals of feldspars with a rhomb-shaped cross-section set in its dark, fine-grained matrix. Unlike all the extrusive rocks on this spread, rhomb porphyry is an intrusive rock – formed from magma underground – like all the rocks on the following spread.

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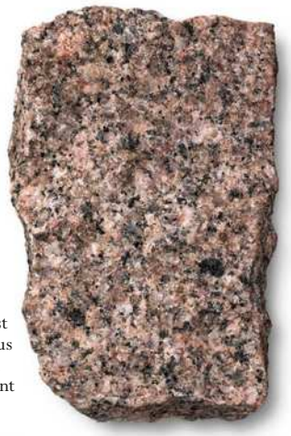
pale plagioclase feldspar

DIORITE
Composed of plagioclase feldspars, with amphiboles and pyroxenes, diorite contains little or no quartz. It is a coarse-grained plutonic rock.



GRANODIORITE
This is probably the most common intrusive igneous rock in the continental crust. It is over 65 per cent plagioclase feldspar.

LARVIKITE
A form of syenite, larvikite is blue-black in colour and composed of large amounts of feldspar that can have a shimmering blue schiller effect.

GRANITE
Coarse-grained and of varying colour, granite contains more than ten per cent quartz. Attractive when polished, it is often used on the facade of buildings.

NEPHELINE SYENITE
Coarse-grained, pale-coloured, and composed of feldspars, micas, and hornblende, this rock also contains nepheline but usually no quartz.

SYENITE
Grey or pinkish, syenite is a plutonic rock that occurs in large intrusions. Coarse-grained, it contains feldspars, micas, and hornblende, and little or no quartz.

LAMPROPHYRE
Lamprophyre's matrix is medium-grained and studded with distinct crystals of micas and amphiboles. It forms in dykes and sills.

light plagioclase feldspar

GABBRO
This dark, plutonic rock contains plagioclase feldspars, pyroxenes, and olivine. Coarse-grained, it forms from the slow cooling of basaltic magma at depth.

LAYERED GABBRO
This type of gabbro shows banding caused by the settling of minerals of different density in the magma.

PORPHYRITIC MICROGRANITE
Larger crystals are set into the matrix of this medium-grained rock, which is composed mainly of quartz, micas, and feldspars.

black tourmaline

OLIVINE GABBRO
Gabbro is a dark, coarse-grained rock with much pyroxene and plagioclase feldspar. Olivine occurs in significant amounts in this variety of gabbro.

BOJITE
A dark-coloured rock, bojite is a general term for hornblende-rich gabbro. It is coarse-grained and forms from magma.

WHITE MICROGRANITE

MICROGRANITE
This medium-grained granite – often with a porphyritic texture – occurs in sills and dykes, which are sheets of intrusive igneous rock.

DOLERITE
Typically occurring in sills and dykes, dolerite is a dark, medium-grained rock composed of plagioclase feldspars, pyroxenes, and iron oxides.

GARNET PERIDOTITE
Peridotite has a composition similar to that of Earth's upper mantle. This dense, greenish variety is made of dark minerals including garnets, olivine, and pyroxenes.

DUNITE
Composed almost entirely of olivine, this rock is dark green or brown, with a medium-grained texture. It usually includes a little chromite.

PERIDOTITE
A dark, dense rock composed mainly of olivine and pyroxenes, peridotite is coarse-grained and forms slowly at great depth.

ADAMELLITE
This type of granite forms at depth with crystals of quartz, micas, and feldspars. One-third to two-thirds of the total feldspar content is plagioclase.

GRAPHIC GRANITE
This coarse-grained rock contains quartz and feldspars, whose intergrowth results in a graphic texture, vaguely resembling runic writing. It also contains micas.

KIMBERLITE
Dark-coloured and coarse-grained, kimberlite has a very low silica content. Of variable composition, it is the world's main source of diamonds.

FELSITE
Fine-grained felsite forms in sheet-like intrusions, sills and dykes. Pale in colour, it is composed mainly of feldspars and quartz.

PEGMATITE
Pegmatites are very coarse-grained rocks, formed from residual liquid magma after most of a granite intrusion has cooled and crystallized. Some pegmatites are an important source of gemstones.

PORPHYRITIC GRANITE
A pale-coloured rock composed of feldspars, quartz, and micas, porphyritic granite has large, well-formed crystals set into the matrix.

HORNBLENDE GRANITE
Granite typically contains quartz, feldspars, and micas. This variety also contains hornblende, a member of the amphibole mineral group.

ANORTHOSITE
Pale-coloured, anorthosite is composed mainly of large crystals of plagioclase feldspars. It can also contain olivine and augite.

METAMORPHIC ROCKS

When existing rocks are subjected to heat or pressure or both within the Earth, they are changed into different assemblages of minerals. Contact metamorphism occurs when intense, localized heat radiating from a body of igneous rock causes the surrounding rocks to recrystallize. Regional metamorphism takes place over wide areas, often at considerable depth, as a result of intense heat and pressure. Movements of Earth's crust can result in rocks being pulverized by dynamic metamorphism.

GRANULITE
Formed at very high temperatures and pressures, granulite is dark, coarse-grained, and rich in pyroxenes, garnets, micas, and feldspars.

SCHIST
Schist is characterized by its parallel planes of similarly oriented minerals within the rock. The corrugated pattern seen on the specimen is called crenulation.

HALLEFLINTA
Originally volcanic tuff, rhyolite, or quartz porphyry, halleflinta is fine-grained, pale-coloured, and rich in quartz. It is a type of hornfels.

MYLONITE
When rocks are pulverized deep within a thrust fault zone, the rock dust and fragments produced form a fine-grained rock called mylonite.

MUSCOVITE SCHIST
A typical schist with pale, glittery muscovite mica, this rock also contains quartz and feldspars.

KYANITE SCHIST
Mainly composed of feldspars, micas, and quartz, this schist also contains crystals of the blue mineral kyanite.

SPOTTED SLATE
This is a dark, fine-grained rock characterized by black spots (porphyroblasts) of minerals, such as cordierite and andalusite.

GARNET SCHIST
The red garnets in this variety of schist indicate that it developed at relatively high temperatures and pressures deep within the continental crust.

BIOTITE SCHIST
Formed at relatively high pressures and temperatures, biotite schist contains feldspars, quartz, and much dark-coloured biotite mica.

SLATE
Dark and very fine-grained, slate is a compact rock with parallel cleavage planes. It is formed by low-pressure metamorphism.

PHYLLITE
Phyllite is formed at lower temperatures and pressures than schist, but higher than slate. It is fine-grained and splits into slabs with a characteristic sheen.

SKARN
Formed when rocks rich in carbonate minerals are altered by high-temperature contact metamorphism, skarn contains minerals rich in calcium, magnesium, and iron.

FULGURITE
When lightning strikes in deserts or on beaches, sand can melt, forming small, tube-shaped structures, called sand fulgurites.

METAQUARTZITE
With a high percentage of quartz, this rock is harder than most metamorphic rocks. It is formed from sandstone altered at high temperature.

CHIASTOLITE HORNFELS
Hornfels forms at very high temperatures near magma intrusions. Bladed crystals of pale chiastolite give this particular variety its name.

CORDIERITE HORNFELS
Dark and splintery, cordierite hornfels is produced by the heat of nearby igneous intrusions. It is fine- to medium-grained.

PYROXENE HORNFELS
Fine- to medium-grained, tough, and flinty, this variety of hornfels contains quartz, micas, and pyroxenes. It forms close to igneous intrusions.

GARNET HORNFELS
Hornfels is a tough, dark, flinty rock formed by the heat from an igneous intrusion. Reddish garnets occur in this particular variety.

GNEISS
A coarse-grained rock formed at very high temperatures and pressures, gneiss is recognized by its alternating dark and light crystalline bands.

AUGEN GNEISS
Gneiss contains quartz, feldspars, and micas, often in parallel bands. Augen gneiss has crystals resembling lens-shaped eyes (*augen* in German).

FOLDED GNEISS
Gneiss becomes plastic and folded at great depth. The dark bands are hornblende-rich and the paler ones are of quartz and feldspars.

AMPHIBOLITE
Formed by moderate heat and varying pressure deep in the crust, this coarse-grained rock has an abundance of hornblende and plagioclase feldspar, as well as other minerals.

ECLOGITE
Composed of two main minerals, green omphacite pyroxene and red garnet, eclogite is coarse-grained and forms at very high temperatures and pressures.

MIGMATITE
Formed at the highest temperatures and pressures, coarse-grained migmatite contains bands of dark basaltic minerals and pale granitic minerals. It is often folded.

GRANULAR GNEISS
This gneiss has a granular texture with equal-sized grains. It has dark bands of hornblende and biotite mica, and pale bands of quartz and feldspars.

GREY MARBLE

MARBLE
Formed by contact or regional metamorphism, marble is rich in calcite, often with colourful veins of other minerals. It is prized as a carving material.

GREEN MARBLE

SERPENTINITE
Commonly banded, speckled, or streaked, serpentinite is a dense, but soft, metamorphic rock derived from peridotite. It is found in convergence zones between tectonic plates.

SEDIMENTARY ROCKS

Sedimentary rocks are generally characterized by stratification, or bedding, and they can contain fossils. These rocks are divided into three groups according to their origin. Clastic rocks are made up of fragments of rocks and minerals eroded from previously formed rocks; organic rocks are derived from the remains of plants and animals; chemical rocks result from the precipitation of chemicals.

MILLET-SEED SANDSTONE
The medium-sized grains of this rock are often coated with reddish iron oxides. The well-rounded, equal-sized quartz grains have been shaped by the wind.

GREENSAND
Coloured greenish by the silicate mineral glauconite, greensand is a quartz-rich sandstone formed in the sea.

MICACEOUS SANDSTONE
Rich in quartz, this sandstone also contains glittery flakes of mica. It usually has medium-sized grains.

LIMONITIC SANDSTONE
This rock is coloured red-brown or yellowish by the iron oxide mineral limonite, which coats its medium quartz grains.

TRAVERTINE
A pale-coloured and often layered rock, travertine is virtually pure calcite. It is formed around hot springs and volcanic vents.

ROCK SALT
Composed of halite, rock salt is often coloured by inclusions of iron oxides and clay minerals. It is soluble in water, with a low hardness and a salty taste.

ROCK GYPSUM
A crystalline rock formed when salt water evaporates, rock gypsum is pale coloured, often fibrous, and very soft. It occurs with other evaporite minerals.

SANDSTONE
This rock typically occurs as layers of sand grains, held together by various mineral cements that impart different colours. Sandstones are quartz-rich.

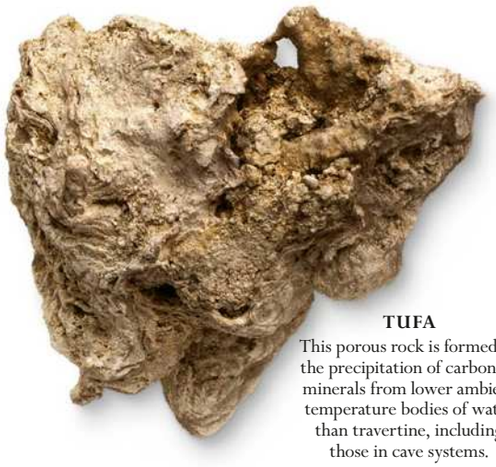
BOULDER CLAY
Grey to brownish in colour, boulder clay, or till, has a very fine-grained clay matrix with glacially derived angular and rounded rock fragments.

CLAYSTONE
Of varying colour, this very fine-grained rock is composed mainly of silicate clay minerals such as kaolinite – mostly derived from the weathering of feldspars.

BANDED IRONSTONE
This rock, deposited in marine or fresh water, has alternating bands of black hematite and red chert. It is one of the best ores of iron.

OOLITIC IRONSTONE
This rock is composed of small, rounded grains (ooliths) of iron minerals, such as siderite, cemented by other iron minerals, as well as by calcite and quartz.

LOESS
A clay with very fine, dust-like grains lifted by the wind from dry land surfaces, loess is crumbly and lacks obvious layering.



TUFA
This porous rock is formed by the precipitation of carbonate minerals from lower ambient temperature bodies of water than travertine, including those in cave systems.

GREY ORTHOQUARTZITE

ORTHOQUARTZITE
Rarely containing fossils, this rock is composed almost entirely of silica-cemented quartz grains. Orthoquartzite is sometimes known as quartz arenite.

PINK ORTHOQUARTZITE

MANGANESE NODULE
Rich in valuable metals such as manganese, iron, nickel, cobalt, and copper, these nodules are rounded, black concretions that form on the deep ocean floor.

layered structure

rounded nodule

LIGNITE

JET

LIGNITE
Lignite is brown coal with a lower carbon content than bituminous coal. Jet is a black, lustrous form of lignite, and will take a high polish.

ANTHRACITE
The purest form of coal, which is derived from plant material, anthracite is black, with a vitreous lustre. It has curved edges when broken.

BITUMINOUS COAL
This sedimentary rock has a lower carbon content than anthracite. Brittle and dull, it is the most abundant type of coal.

internal radiating structure

pale calcite filling cracks (septa)

SEPTARIAN NODULE
This type of concretion occurs in sedimentary rocks as individual, rounded masses. Internally, cracks known as septa are infilled by quartz or calcite.

PYRITE NODULE
These spherical nodules occur in shale and clay, and are composed entirely of radiating crystals of pyrite.

»

» SEDIMENTARY ROCKS

NUMMULITIC LIMESTONE
A marine foraminiferan, *Nummulites* is the main fossil in this rock. The cement is calcite, originally lime mud.

CRINOIDAL LIMESTONE
Crinoids are echinoderms that are attached to the seabed by a flexible stalk. Crinoidal limestone is a mass of broken stalks cemented by hardened lime mud.

CORAL LIMESTONE
This rock is a mass of fossilized corals cemented by fine-grained calcite. It is grey to white or brownish in colour.

FRESHWATER LIMESTONE
This limestone is a pale, calcite-rich rock with some quartz and clay. It contains fossils of freshwater organisms, which indicate the environment of deposition.

PISOLITIC LIMESTONE
This rock is composed of pisoliths – pea-sized grains slightly larger than ooliths, often flattened, and loosely cemented by calcite.

OOLITIC LIMESTONE
This limestone is composed of ooliths – small, rounded, concentrically banded grains rolled by seabed currents and cemented by carbonate mud.

BRYOZOAN LIMESTONE
This is a grey or reddish organic limestone, which contains fossils of bryozoans in a matrix of hardened, calcite-rich mud.

LIMESTONE BRECCIA
Often forming below limestone cliffs, this breccia comprises large, angular fragments of limestone and other rocks, cemented by calcite.

FELDSPATHIC GRITSTONE
Coarse-grained and pale- to dark-coloured, this gritstone contains much quartz and up to 25 per cent feldspar.

QUARTZ GRITSTONE
This gritstone is composed of quartz with some feldspar and mica, all of coarse grain size.

GREYWACKE
This dark rock contains quartz, rock fragments, and feldspars, set in a mass of finer clay and chlorite. It forms in marine basins.

ARKOSE
Variable in colour and medium-grained, arkose is a sandstone with a high percentage of feldspar.

DOLOMITE
This yellowish brown or grey rock contains a high percentage of dolomite (calcium magnesium carbonate). It is also called dolostone, to distinguish it from this mineral.

FOSSILIFEROUS SHALE
Fine-grained marine sedimentary rocks such as shale often contain large numbers of well-preserved fossils.

SHALE
This fine-grained, layered rock varies in composition, usually containing silt, clay minerals, organic materials, iron oxides, and minute crystals of minerals such as pyrite and gypsum.

POLYGENETIC CONGLOMERATE
A coarse-grained sedimentary rock, polygenetic conglomerate has many different, rounded rock and mineral fragments in a finer grained matrix.

QUARTZ CONGLOMERATE
Varying in colour, this rock typically has dirty white, pebble-sized, rounded quartz fragments set in a finer, darker matrix.

RED CHALK

CHALK
Pure calcite, chalk is very fine-grained and powdery. It is composed of minute fossilized organisms, including coccoliths and radiolarians.

WHITE CHALK

SILTSTONE
This dark-coloured rock comprises particles, mainly of quartz, which are smaller than fine sand but larger than clay grains. It can also contain organic material and calcite.

BRECCIA
Containing large, angular fragments of rocks and minerals set in a finer matrix of sand or silt, breccia rarely forms in layers.

MARL
Intermediate between clay and limestone, marl is a fine-grained, calcite-rich, layered rock. Chlorite and glauconite can give it a green colouring.

MUDSTONE
Composed of clay, with fine-grained quartz and feldspars, mudstone lacks the bedding found in shale.

CHERT
A very fine-grained form of silica, chert occurs as bands and nodules in rocks such as limestone. It is usually grey coloured.

FLINT
Usually found as nodules in chalk, flint is very hard, black, compact silica. It breaks leaving sharp, curved edges.

FOSSILS

Fossils are evidence of past life that has been buried and preserved in the rocks of Earth's crust. They give scientists important clues about how life has evolved, and they can also be used to date rocks, and create a timeline of the events that have shaped our world.

Over time the tissues of this plant have decayed. Only the outline remains, covered by a thin film of carbon.

An insect became stuck in resin oozing from a tree. The resin turned into amber, perfectly preserving the creature.

This fish skeleton has been fossilized in shale. Here all the pores in the original skeleton have been infilled by minerals.

Life has existed on Earth for at least 3.7 billion years. Initially, living things were small and soft-bodied, and left few obvious traces of their existence. But during the past billion years, life gradually changed. Organisms evolved hard body parts, which – given enough time – could fossilize. The significance of this change is hard to overstate. It turned the world's sedimentary rocks into a global data bank, teeming with an incredible array of fossilized species, arranged in the exact order in which they appeared. These fossils show the path evolution has followed. They also highlight mass extinctions – when enormous numbers of species have been wiped out in a relatively short space of time.

DEAD AND BURIED

Fossilization is a lottery, and only a small fraction of living organisms end up being preserved. On land, it is usually triggered by chance events – for example, when animals are overwhelmed by landslides or flash floods, or when they drown in lakes. Marine animals have a much better chance of being fossilized, because sediment routinely accumulates over their dead remains. Fine sediment can preserve soft bodies, but the best fossils are left by animals with hard body parts, such as shells or bones. After burial, the remains are slowly infiltrated by dissolved minerals, which literally turns them to stone. Once formed, many fossils are destroyed by heat, pressure, or geological movements while still deep underground. But if a fossil survives all this, uplift may eventually bring it back to the surface, where erosion can release it from its parent rock (see panel, below). There, it has to be found before it eventually breaks apart.

These body fossils can be breathtaking objects, particularly when they are complete skeletons several metres long. However, they are not the only kind of fossilized remains. Rocks can also yield trace fossils, which are fossilized footprints, burrows, or other signs of animal activity. Trace fossils provide indirect but fascinating evidence of how animals lived: for example, dinosaur footprints can show how fast they moved, how they interacted in herds, and even how they put on weight as they grew.

Much further back in time, rocks sometimes contain chemical fossils – ancient carbon-based compounds that have been produced by biological processes. Although unspectacular, these chemical smudges are key evidence in the hunt for Earth's earliest living things.

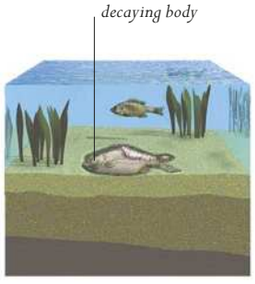
SUDDEN DEATH >
Trilobites from the Late Ordovician Period are fossilized together, suggesting the sudden burial of these animals by sediment.

DEBATE

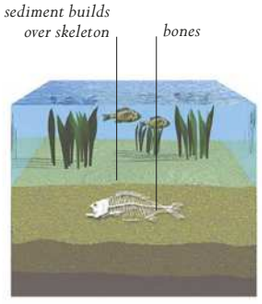
INDEX FOSSILS

The geological timescale was largely established using fossils. Species which lived across a wide geographical range, but only existed for a short time, are known as index fossils. They can be used to identify particular strata and link them from place to place – the presence of the same index fossil in different places shows that the strata were laid down at the same time. Index fossils therefore help geologists to date rocks and build a relative time sequence. Mesozoic ammonites (a group of extinct marine molluscs) are among the best index fossils – an ammonite zone may be as little as a million years.

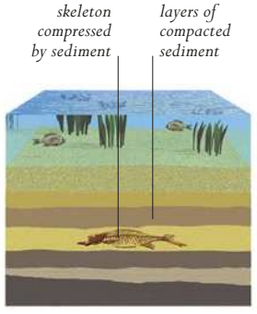
HOW FOSSILS FORM



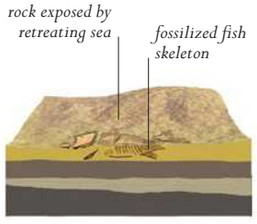
A dead fish lies on the seabed, where its flesh may rot or be eaten. To be preserved, it must be buried rapidly. As the mud turns into shale, this change will compress and flatten the body.



The fish skeleton has been covered by sediment. To become fossilized, the bones must undergo a chemical change, called permineralization, where the pores in the bone are replaced by minerals.



More sediment has accumulated on the seabed and compressed the lower layers. The sediment is compressed and the fossil may become flattened, distorted, or destroyed.



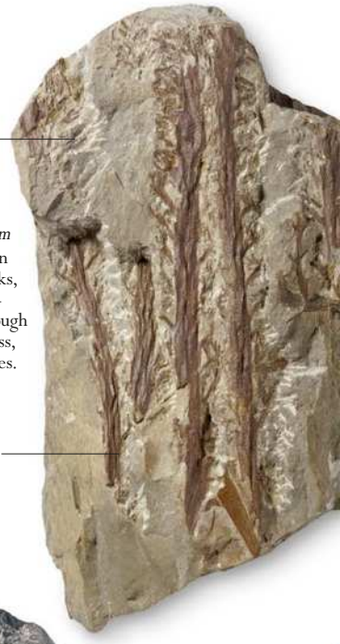
Millions of years later the seabed sediment, now turned to rock, has been exposed by retreating seas. Weathering has further denuded the rock around the fossilized fish skeleton.

FOSSIL PLANTS

Plants are among the first organisms to appear in the fossil record. Algae are found in rocks from the Precambrian. Vascular plants (plants with tissues for conducting water and nutrients) evolved in the Silurian Period, and by Carboniferous times, Earth was coloured green by vast, coal-forming swamp forests. Flowering plants developed later, in the Mesozoic Era.

EARLY LAND PLANT
Cooksonia hemisphaerica
Found in Silurian and Devonian rocks, *Cooksonia* was one of the earliest vascular plants. It had a stiff stem and leafless branches.

CALAMOPHYTON STEMS
Calamophyton primaevum
A primitive, leafless plant, probably related to ferns, *Calamophyton* is found in Devonian and Early Carboniferous rocks.



CLADOXYLON STEMS
Cladoxylon scoparium
Fossilized in Devonian and Carboniferous rocks, *Cladoxylon* was a low-growing plant, with a tough central stem and leafless, light-absorbing branches.

SEED FERN LEAF
Alethopteris serlii
A seed fern from Carboniferous and Permian strata, *Alethopteris* had compound pinnate fronds, consisting of thick, strongly veined leaflets.

CYCLOPTERIS LEAFLETS
Cyclopteris orbicularis
Oval leaflets from a seed fern called *Neuropteris* are given the scientific name *Cyclopteris*. Its fossils belong to Carboniferous strata.

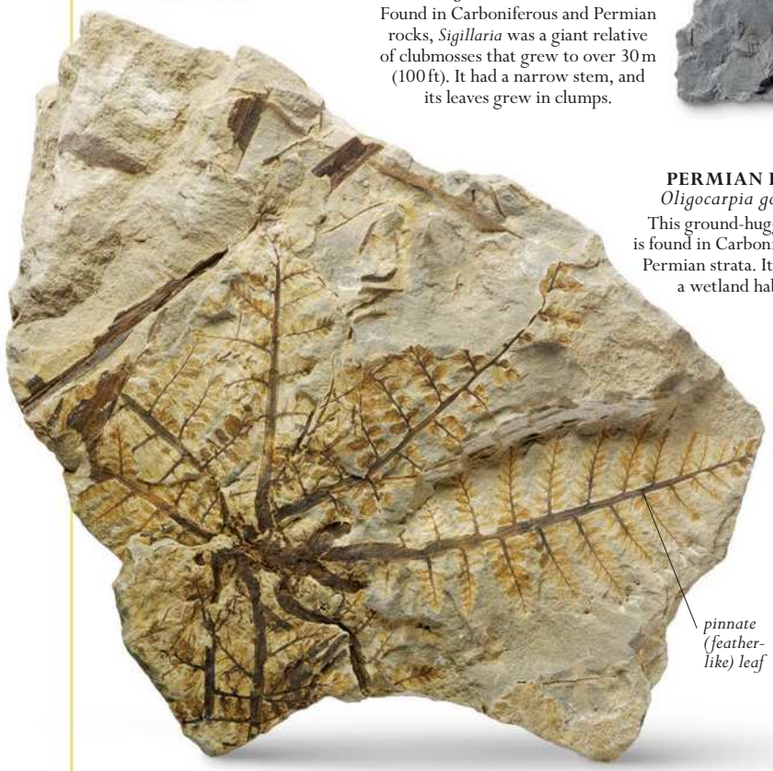
SEED FERN SEEDS
Trigonocarpus adamsi
The name *Trigonocarpus* is given to fossil seeds from seed ferns found in Carboniferous strata. Each seed has three ribs.

HORSETAIL FOLIAGE
Asterophyllites equisetiformis
Found in Carboniferous and Permian strata, *Asterophyllites* had needle-shaped leaves and a structure similar to that of modern horsetails.

CLIMBING HORSETAIL
Sphenophyllum emarginatum
Found fossilized in rocks of Carboniferous to Permian age, this horsetail had wedge-shaped leaves and long, soft stems adapted for climbing.

SIGILLARIA STEM
Sigillaria aeveolaris
Found in Carboniferous and Permian rocks, *Sigillaria* was a giant relative of clubmosses that grew to over 30 m (100 ft). It had a narrow stem, and its leaves grew in clumps.

LEPIDODENDRON ROOT
Stigmaria ficoides
Occurring in Carboniferous to Permian rocks, *Stigmaria* is the name for the fossil roots of the clubmoss relative, *Lepidodendron*.



PERMIAN FERN
Oligocarpia gothanii
This ground-hugging fern is found in Carboniferous and Permian strata. It occupied a wetland habitat.

SALVINIA RHIZOME
Salvinia formosa
A floating water fern from the tropics, *Salvinia* is found fossilized in rocks from Cretaceous to recent strata.

CRETACEOUS FERN
Weichselia reticulata
Found fossilized in Cretaceous strata, *Weichselia* was similar to modern bracken and had fronds that were divided twice.

SEED FERN LEAFLETS
Dicrodium sp.
A seed fern from the Triassic Period, *Dicrodium* had pinnate leaves and its fronds were about 7.5 cm (3 in) long.

PALEOZOIC CONIFER
Lebachia piniformis
A cone-bearing plant from Carboniferous and Permian strata, *Lebachia* is an ancestor of modern conifers.

CONIFER SEED CONES
Taxodium dubium
Found in Jurassic strata, *Taxodium* is related to modern cypress trees. It grew in damp habitats and had needle-like leaves.

COAST REDWOOD CONE
Sequoia dakotensis
Cones of the giant evergreen tree *Sequoia* have been found in Cretaceous and recent rocks. Some living members of *Sequoia* are over 2,000 years old.

CRETACEOUS CONIFER
Glyptostrobus sp.
This conifer grew in swamps during the Cretaceous Period and into the Cenozoic Era. *Glyptostrobus* was an important coal-forming tree.

SUBFOSSIL TREE RESIN
Kauri pine amber
Amber is the hardened resin from pine trees, such as Kauri pines. First occurring in the Early Cretaceous, it often contains fossils of insects that perished on the fragrant, sticky resin.

JURASSIC CONIFER
Araucaria mirabilis
This extinct species of monkey puzzle tree, *A. mirabilis*, bore characteristic female cones with spirally arranged scales attached to a central axis.

CARBONIFEROUS GYMNOSPERM
Cordaites sp.
An ancestor of the conifers, *Cordaites* grew during the Carboniferous and Permian Periods. It was a tree-sized plant, which reproduced by seed.

GIGANTOPTERID LEAVES
Gigantopteris nicotianaefolia
A flowerless plant from Permian times, this species was so named because its leaves resembled those of tobacco plants.

PERMIAN GINKGO LEAVES
Psygmophyllum multipartitum
Still found in China, ginkgos first appeared in the Permian Period. The fan-shaped leaves can be identified in fossils of *Psygmophyllum*, a precursor of the modern-day ginkgo.

TRIASSIC GINKGO
Baiera munsteriana
Growing up to 15 cm (6 in) in length, the fan-shaped leaves of *Baiera* were split into separate ribs. In living ginkgos, the leaves are almost entire.

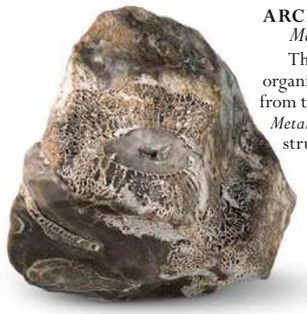
OAK TREE TRUNK
Quercus sp.
The well-known oak genus, *Quercus,* first occurs as fossils in Cretaceous strata. There are over 500 species of oak living today.

STEMLESS PALM FRUIT
Nypa burtinii
Fossils of *Nypa* date from the Eocene Period onwards. This palm holds its woody seeds in a 25 cm (10 in) ball-shaped fruit.

MAGNOLIA LEAF
Magnolia longipetiolata
One of the earliest genera of flowering plants, magnolias first appeared in the Cretaceous Period. Early insects fed on their nectar.

FOSSIL INVERTEBRATES

Invertebrates, animals without a solid internal skeleton, are among the most common fossils found. They first appeared in the Precambrian, but it is only in Early Cambrian times that complex invertebrates such as trilobites become numerous in the fossil record. Fossils of invertebrates such as arthropods, molluscs, brachiopods, echinoderms, and corals are especially common, because they had hard external structures and lived in the sea, where most fossil-bearing rocks form.



ARCHAEOCYATHID
Metaldetes taylori
These reef-building organisms are known only from the Cambrian Period. *Metaldetes* had a cup-like structure, not unlike that of a coral.

CALCAREOUS SPONGE
Peronidella pistilliformis
Characterized by needle-like spicules (in the form of calcite) fused together, *Peronidella* is found in Triassic and Cretaceous rocks.

STROMATOPOROID
Stromatopora concentrica
Found in rocks ranging from the Ordovician to the Permian, often in reef limestone, the fossil sponges in this group were made of porous, calcium-rich tubes.

CHEILOSTOME BRYOZOAN
Biflustra sp.
Found in Cenozoic rocks, the *Biflustra* genus is extant. These bryozoans have minute compartments, which house zooids – the soft-bodied individuals of a colony.

TREPOSTOME BRYOZOAN
Diplotrypa sp.
A bryozoan from Ordovician strata, *Diplotrypa* was a small invertebrate, not unlike coral, that lived in dome-shaped colonies.

BRANCHING BRYOZOAN
Constellaria sp.
A bryozoan that built branching colonies on the seabed, *Constellaria* occurs in Ordovician strata.

LACE CORAL
Schizoretepora notopachys
A lace coral, *Schizoretepora* is found in Eocene to Pleistocene strata. It lived on rocky seabeds.

SERPULID WORMS
Rotularia bognoriensis
Found in Jurassic to Eocene rocks, *Rotularia* is a genus of serpulid worm. Like all serpulids, each worm protected its soft body by producing coiled tubes made of calcium carbonate.

SPRIGGINA
Spriggina floundersi
A very early fossil found in Ediacaran rocks, *Spriggina* had a long, worm-like body. Its classification is uncertain.

SPIRAL GRAPTOLITE
Monograptus convolutus
A single branch, with thecae (cup-like structures) on one side, characterizes *Monograptus,* which is found in Early Silurian strata. *M. convolutus* had unusual coiling.

BRANCHING GRAPTOLITE
Rhabdinopora socialis
Until recently, this graptolite was called *Dictyonema*. It had numerous thin, radiating stipes, and is from Ordovician strata.

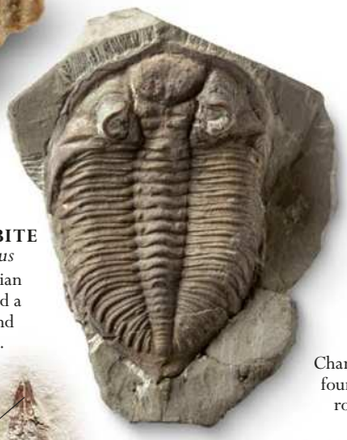
"TUNING FORK" GRAPTOLITE
Didymograptus murchisoni
A graptolite (extinct colonial invertebrate) with two stipes (branches), *Didymograptus* is found in Ordovician rocks. It grew from 2–60 cm (¾–23½ in) in length.

TABULATE CORAL
Catenipora sp.
A simple, tabulate coral with a chain-like structure, *Catenipora* lived in warm, shallow seas during Ordovician and Silurian times.

SCLERACTINIAN CORAL
Meandrina sp.
Shaped like the human brain, this colonial coral has ridges and valleys on its surface. First found in Eocene rocks, *Meandrina* still survives today.

RUGOSE CORAL
Goniophyllum pyramidale
A solitary coral occurring in Silurian rocks, *Goniophyllum* has a cone-shaped structure in which the polyp lived.

CAMBRIAN TRILOBITE
Paradoxides bohemicus
Some *Paradoxides* trilobites grew to nearly 1 m (3¼ ft) in length. This species had long spines on its body and is from Cambrian strata.

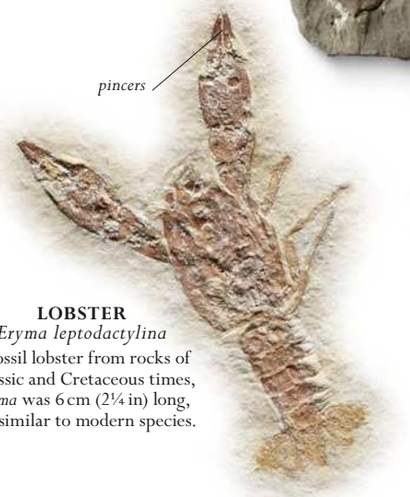


SILURIAN TRILOBITE
Dalmanites caudatus
Common in the Silurian Period, *Dalmanites* had a segmented thorax and a pointed tail spine.

DEVONIAN ENROLLED TRILOBITE
Phacops sp.
Characterized by compound eyes, *Phacops* is found in Devonian strata. Trilobites could roll up, like many modern arthropods.

ORDOVICIAN TRILOBITE
Eodalmanitina macrophtalma
An Ordovician trilobite, *Eodalmanitina* had large, crescent-shaped eyes. Its thorax was composed of 11 segments.

HORSESHOE CRAB RELATIVE
Euproops rotundatus
A Carboniferous relative of horseshoe crabs, *Euproops* had a crescent-shaped headshield and long tail spine.



LOBSTER
Eryma leptodactylina
A fossil lobster from rocks of Jurassic and Cretaceous times, *Eryma* was 6 cm (2¼ in) long, and similar to modern species.

CRAB
Avitelmessus grapsoideus
Covered with many spines, this crab is from the Cretaceous Period. It grew to 25 cm (10 in) in width.

COCKROACH RELATIVE
Archimylacris eggintoni
A relative of cockroaches from the Carboniferous Period, *Archimylacris* had hind wings with a distinctive vein pattern.

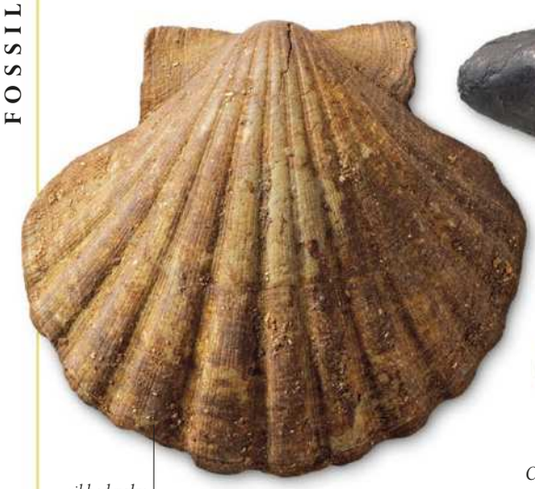
»

» FOSSIL INVERTEBRATES

ARTICULATE BRACHIOPOD
Leptaena rhomboidalis
A brachiopod from Ordovician, Silurian, and Devonian strata, *Leptaena* grew to about 5 cm (2 in) in width. Its shell had concentric and radial ribs.

RHYNCHONELLID BRACHIOPOD
Homeorhynchia acuta
Found in Early Jurassic strata, *Homeorhynchia* was a small brachiopod that grew to about 1 cm (⅜ in) in width.

SPIRIFERID BRACHIOPOD
Spiriferina walcotti
A common brachiopod from Triassic and Jurassic strata, *Spiriferina* had a rounded shell up to 3 cm (1¼ in) wide, with clearly visible growth lines.



SCALLOP
Pecten maximus
Found in Paleogene to recent rocks, *Pecten* is a genus of bivalve molluscs. *P. maximus* is extant and swims by flapping its valves.

SWAMP CLAM
Carbonicola pseudorobusta
Occurring in non-marine rocks of the Carboniferous Period, *Carbonicola* had a tapered shell. Its fossils have been used in the relative dating of these rocks.

CLAM
Crassatella lamellosa
A small bivalve from Cretaceous to Miocene times, *Crassatella* had marked concentric growth lines on its shell.

MUSSEL RELATIVE
Ambonychia sp.
Found in Ordovician strata, *Ambonychia*, an early bivalve mollusc, grew up to 6 cm (2½ in) wide. Both valves had radial ribs on the surface.

DEVIL'S TOENAIL
Gryphaea arcuata
This fossil oyster occurs in Triassic and Jurassic rocks. *Gryphaea* had one large, hooked valve and a smaller, flat one.

DEVONIAN GASTROPOD
Murchisonia bilineata
A gastropod mollusc from Silurian to Permian strata, *Murchisonia* grew up to 5 cm (2 in) tall, with ridges around its whorls.

JURASSIC GASTROPOD
Pleurotomaria anglica
Found in Jurassic and Cretaceous rocks, this gastropod mollusc had a broad shell with a combination of radial and spiral patterns.

ROSTROCONCH
Conocardium sp.
Occurring in Devonian and Carboniferous strata, *Conocardium* resembled clams, but its shell had no functional hinge.

NAUTILOID
Vestinautilus caniferous
This early *Nautilus* relative had very open coiling and little shell ornamentation. *Vestinautilus* is found in Carboniferous rocks.

DEVONIAN AMMONOID
Soliclymenia paradoxa
An Early Devonian ammonoid, *Soliclymenia* had thin ribs across the shell. Some species had an unusual, triangular shell.

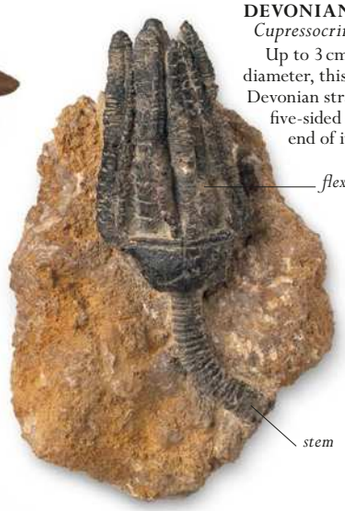
CARBONIFEROUS AMMONOID
Goniatites crenistria
An ammonoid mollusc from Devonian and Carboniferous rocks, *Goniatites* had angular sutures where the chamber walls joined the shell.

TRIASSIC AMMONOID
Ceratites nodosus
Found in Triassic strata, *Ceratites* was an ammonoid mollusc. Its heavily ornamented shell had open coiling and strong ribs.

AMMONITE
Mortoniceras rostratum
This ammonite mollusc from the Cretaceous Period grew up to 10 cm (4 in) in diameter, with ribs across the shell.

BELEMNITE
Pachyteuthis abbreviata
A squid relative from the Jurassic, *Pachyteuthis* had a calcite guard. It was about 10 cm (4 in) long.

CYSTOID
Pseudocrinites bifasciatus
Characterized by rhomboid-shaped respiratory structures, *Pseudocrinites* lived in Silurian and Devonian times. It was attached to the seabed by its stem.



DEVONIAN CRINOID
Cupressocrinites crassus
Up to 3 cm (1¼ in) in diameter, this crinoid from Devonian strata had a tall, five-sided cup at the end of its stem.

JURASSIC CRINOID
Pentacrinites sp.
Named for its five-sided ossicles (stem segments), *Pentacrinites* grew to over 1 m (3¼ ft) in height. It is often found attached to fossil wood.

BRITTLESTAR
Lapworthura miltoni
An early fossil brittlestar, *Lapworthura* is from Ordovician and Silurian strata. It grew to 10 cm (4 in) in diameter. This species had five relatively short, thick arms.

STARFISH
Tropidaster pectinatus
This extinct starfish from the Early Jurassic was about 2.5 cm (1 in) wide. It had five thick arms.

BLASTOID
Pentremites pyriformis
This echinoderm from the blastoid group lived during Carboniferous times. It had long, arm-like structures that were used for feeding.

SEA URCHIN
Hemicidaris intermedia
This common sea urchin from Jurassic strata grew to around 4 cm (1½ in) in diameter. Its many bumps (tubercles) supported stout spines.

HEART URCHIN
Lovenia sp.
A heart-shaped, burrowing sea urchin, *Lovenia* is known from the Palaeocene and still exists today. It is up to 5 cm (2 in) in diameter.

FOSSIL VERTEBRATES

Fossilized vertebrate remains are not as common as those of invertebrates, since many vertebrates lived on land, where fewer fossils form, and they evolved much later than the invertebrates. Fish were the earliest vertebrates to evolve, some dating back to Cambrian times. Their rapid evolution in the Silurian and Devonian led to amphibians, which first appeared in the Devonian Period. Dinosaurs flourished during the Mesozoic Era, towards the end of which mammals began to diversify.

ZENASPID FISH
Zenaspis sp.
Found in Devonian strata, *Zenaspis* had a massive headshield. Up to 25 cm (10 in) long, its body was covered in bony scales.

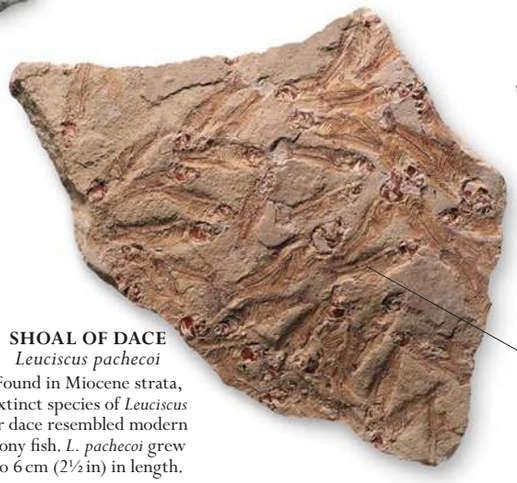
EARLY FISH-LIKE VERTEBRATE
Loganellia sp.
A primitive, jawless, flattened "fish", *Loganellia* was covered with tooth-like scales. Up to 12 cm (4¾ in) long, it is found in Devonian rocks.

PSAMMOSTEID FISH
Drepanaspis sp.
A jawless, primitive fish, *Drepanaspis* had a flattened headshield. It is found only in Devonian strata.

LOBE-FINNED FISH
Eusthenopteron foordi
The bones in the heavily built fins of this Late Devonian fish were similar to those in the limbs of land-dwelling vertebrates (tetrapods).

PLACODERM
Bothriolepis canadensis
A Devonian placoderm (an extinct group of jawless fish), *Bothriolepis* had large head- and trunk-shields and spine-like pectoral fins.

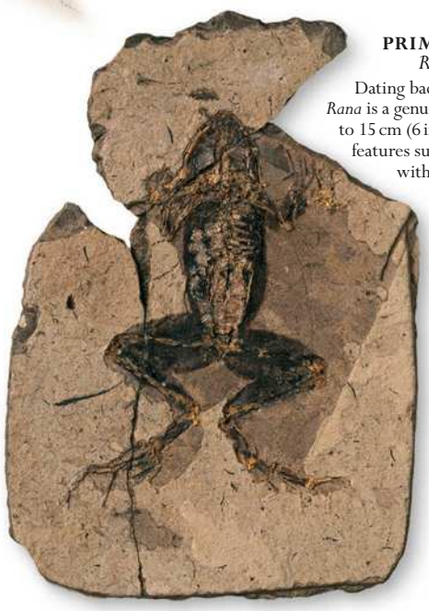
SHARK TOOTH
Otodus sokolovi
The serrated edges of the teeth of this Cenozoic shark could easily cut through flesh.



SHOAL OF DACE
Leuciscus pachecoi
Found in Miocene strata, extinct species of *Leuciscus* or dace resembled modern bony fish. *L. pachecoi* grew to 6 cm (2½ in) in length.

STINGRAY
Heliobatis radians
Found in Eocene strata, *Heliobatis* was a freshwater stingray that grew to about 30 cm (12 in) in length and had a skeleton of cartilage.

SKULL OF LARGE, PREDATORY BONY FISH
Xiphactinus sp.
A bony fish from Late Cretaceous strata, *Xiphactinus* was a marine predator with a muscular body and large front teeth.



PRIMITIVE FROG
Rana pueyoi
Dating back to Miocene times, *Rana* is a genus of frogs. *R. pueyoi* grew to 15 cm (6 in) in length and shared features such as long hind limbs with modern frogs.

DIPLOCAULID AMPHIBIAN
Diplocaulus magnicornis
A salamander-like amphibian from the Permian Period, *Diplocaulus* had protrusions on the sides of its skull. It grew up to 1 m (3¼ ft) in length.

GIANT MONITOR LIZARD VERTEBRA
Varanus priscus
A huge monitor lizard, *Varanus priscus* grew to 7 m (23 ft) in length. It is found in rocks of Pleistocene age.

CYNODONT SKULL
Cynognathus crateronotus
A carnivore with a stout skull and large canine teeth, *Cynognathus* belonged to a group of mammal precursors called cynodonts. It is found in Triassic strata.

DIMETRODON SKULL
Dimetrodon loomisi
Noted for a sail-like structure on its back, *Dimetrodon* was an early relative of mammals from the Permian Period. A high skull and short snout translated into a powerful bite.

DICYNODONT SKULL
Pelanomodon sp.
This tuskless herbivore was a dicynodont – a member of a group of mammal relatives that lived in the Permian and Triassic Periods.

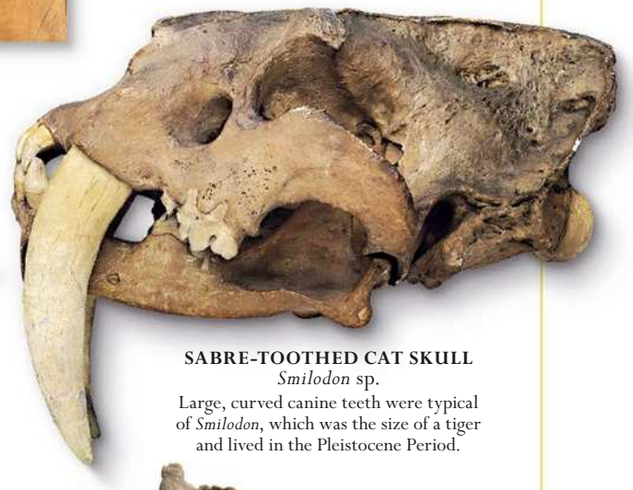
PLESIOSAUR FLIPPER
Cryptoclidus eurymerus
Growing up to 8 m (26 ft) in length, *Cryptoclidus* was a long-necked plesiosaur from the Jurassic Period.

MARINE TURTLE SKULL
Puppigerus crassicostata
Fossilized marine turtles are found in rocks ranging from the Mesozoic Era to Recent times. *Puppigerus* had a heavy shell and is found in Eocene strata.

EARLIEST BIRD
Archaeopteryx lithographica
Archaeopteryx was thought to be the earliest bird. However, recent finds in Jurassic rocks in China are challenging that view.

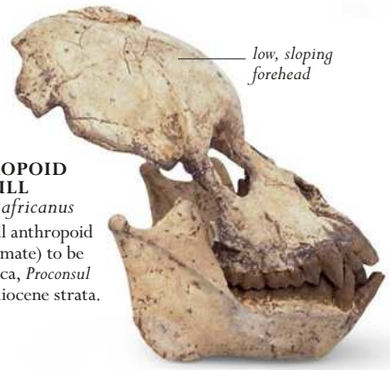
GIANT GROUNDBIRD SKULL
Phorusrhacos inflatus
A carnivore up to 2.5 m (8¼ ft) tall, *Phorusrhacos* was a flightless bird with a powerful beak. It is found in Miocene rocks.

EARLY HORSE TEETH
Protorohippus sp.
A dog-sized, many-toed ancestor of the modern horse, *Protorohippus* is found in Eocene strata. It had low-crowned molars.



SABRE-TOOTHED CAT SKULL
Smilodon sp.
Large, curved canine teeth were typical of *Smilodon*, which was the size of a tiger and lived in the Pleistocene Period.

EARLY ELEPHANT JAW
Phiomia serridens
Found in Eocene to Oligocene strata, *Phiomia* was 2.5 m (8¼ ft) tall. It had tusks in its upper jaw, and a small trunk.



ANTHROPOID SKULL
Proconsul africanus
The first fossil anthropoid (ape-like primate) to be found in Africa, *Proconsul* comes from Miocene strata.

NOTOUNGULATE
Toxodon platensis
Growing to about 2.7 m (8¾ ft), *Toxodon* had a sturdy body with a hippopotamus-like head. It lived from Pliocene to Pleistocene times.

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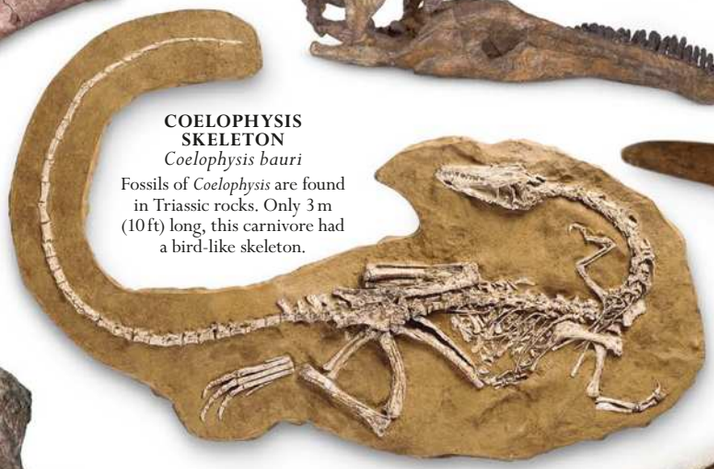
DIPLODOCUS TAIL VERTEBRA
Diplodocus longus
Found in Jurassic strata, *Diplodocus* was a giant plant-eater that grew up to 27 m (89 ft) in length. Its tail was long and whip-like.

BRACHIOSAURUS THIGH BONE
Brachiosaurus sp.
A huge, plant-eating dinosaur that grew to 25 m (82 ft) in length, *Brachiosaurus* lived in the Jurassic and Cretaceous Periods.

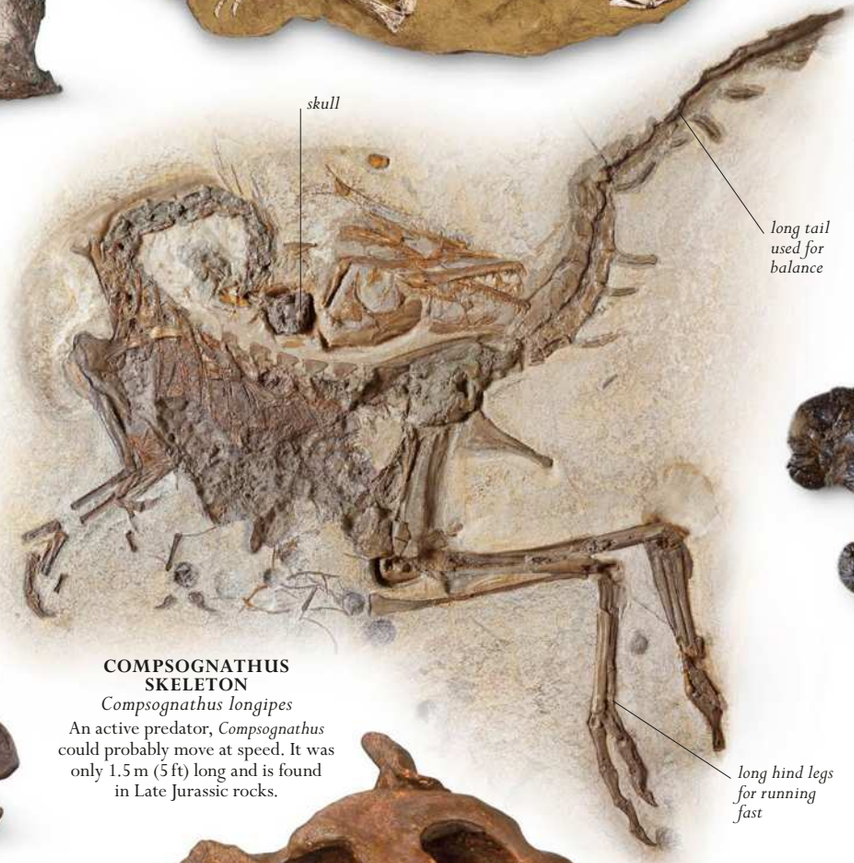
PLATEOSAURUS SKULL
Plateosaurus sp.
A bulky plant-eater from the Late Triassic, *Plateosaurus* grew to about 8 m (26 ft) in length and had a very small head.



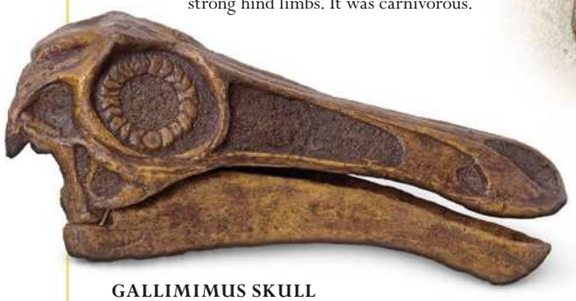
COELOPHYSIS SKELETON
Coelophysis bauri
Fossils of *Coelophysis* are found in Triassic rocks. Only 3 m (10 ft) long, this carnivore had a bird-like skeleton.

PROCERATOSAURUS PARTIAL SKULL
Proceratosaurus bradleyi
A carnivore from Middle Jurassic strata in Gloucestershire, England, *Proceratosaurus* had a bony crest on its head.

MEGALOSAURUS SACRAL VERTEBRAE
Megalosaurus bucklandi
Found in Middle Jurassic strata, *Megalosaurus* was 9 m (30 ft) long, with a large head and strong hind limbs. It was carnivorous.



COMPSOGNATHUS SKELETON
Compsognathus longipes
An active predator, *Compsognathus* could probably move at speed. It was only 1.5 m (5 ft) long and is found in Late Jurassic rocks.



GALLIMIMUS SKULL
Gallimimus bullatus
Growing up to 6 m (20 ft) long, *Gallimimus* had a bird-like, beaked skull, and long neck and legs.

ALBERTOSAURUS SKULL
Albertosaurus sp.
A predator and close relative of *Tyrannosaurus rex*, *Albertosaurus* grew to 8 m (26 ft) in length and is found in Late Cretaceous rocks.

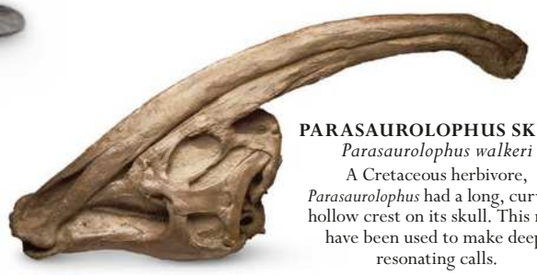
DASPLETOSAURUS JAW
Daspletosaurus torosus
This Cretaceous dinosaur had massive hind legs and small arms, and it grew to a length of 9 m (30 ft). It had a powerful jaw with the formidable teeth of a carnivore.

SCELIDOSAURUS FOOT
Scelidosaurus harrisonii
Found in Early Jurassic rocks, *Scelidosaurus* grew to 4 m (13 ft) in length and was covered with sharp, bony knobs. It had long toes and blunt claws.

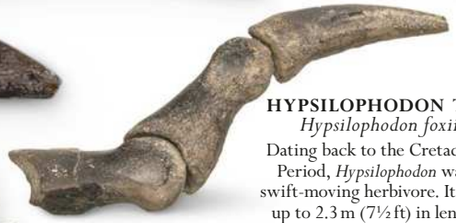
STEGOSAURUS PLATE
Stegosaurus sp.
A Late Jurassic plant-eater, *Stegosaurus* grew up to 9 m (30 ft) in length. It had two rows of huge bony plates running along its back.

ANKYLOSAURUS SKULL
Ankylosaurus magniventris
Found in Cretaceous rocks, *Ankylosaurus* was a heavily armoured plant-eater. It grew to about 6 m (20 ft) in length.

EUOPLOCEPHALUS TAIL CLUB
Euoplocephalus tutus
Growing to 7 m (23 ft) in length, *Euoplocephalus* lived in the Late Cretaceous. A bony club at the tip of its tail was probably used for defence.



PARASAUROLOPHUS SKULL
Parasaurolophus walkeri
A Cretaceous herbivore, *Parasaurolophus* had a long, curved, hollow crest on its skull. This may have been used to make deep, resonating calls.



HYPSILOPHODON TOE
Hypsilophodon foxii
Dating back to the Cretaceous Period, *Hypsilophodon* was a swift-moving herbivore. It grew up to 2.3 m (7½ ft) in length.

PACHYCEPHALOSAURUS SKULL
Pachycephalosaurus wyomingensis
Living at the end of the Cretaceous Period, *Pachycephalosaurus* had a thick, domed skull and grew up to 5 m (16 ft) in length.

STEGOCERAS SKULL
Stegoceras validum
Found in Cretaceous strata, *Stegoceras* grew to 2 m (6½ ft) in length. Its small, serrated teeth indicate it was probably a herbivore.

STYRACOSAURUS SKULL
Styracosaurus albertensis
Although similar to *Triceratops*, *Styracosaurus* had slender horns along the back of its skull. It is found in Late Cretaceous rocks.

TRICERATOPS SKULL
Triceratops prorsus
A massive horned and plated skull characterized *Triceratops*, a plant-eater from Late Cretaceous strata.

PSITTACOSAURUS SKELETON
Psittacosaurus sp.
One of the earliest horned dinosaurs, *Psittacosaurus* is found in Cretaceous strata. It was a plant-eater and grew to 2 m (6½ ft) in length.

EUOPLOCEPHALUS

Euoplocephalus belonged to a family of dinosaurs called the ankylosaurids, which were characterized by an armoured head and bony plating on the body. This dinosaur grew to about 6 m (20 ft) in length and weighed around two tonnes. Its tail, body, and neck were covered by plates and bands of tough, leathery skin set with bony studs. Two rows of larger spikes ran along its back. Even its eyes were protected by bony eyelids. Fused bony knobs on the end of the long tail formed a tail club, which the dinosaur could swing at attacking predators. *Euoplocephalus* was a herbivore – its beaked mouth was ideally suited for grazing on vegetation in the thick forests of the Late Cretaceous. It may even have used the blunt hoofs at the end of each toe to dig in the ground for roots and tubers. *Euoplocephalus* was probably a solitary dinosaur, though juveniles may have lived in herds.

SIZE 6 m (20 ft)
DATE Late Cretaceous
DISTRIBUTION N. America
GROUP Ankylosaurids

ARMOURED HEAD >
The head had a massive skull, with protective spikes at the back and a beaked mouth. The name *Euoplocephalus* means "well armoured head".

v NECK VERTEBRAE
Although the head was relatively small and the neck short, the neck vertebrae had to be strong to support the head's weighty, studded armour plating.

< STUDDED PLATES
One of the most important features of *Euoplocephalus* was its armour plating. This was made of tough plates of skin studded with ridged ovals of bone.

^ FRONT FOOT
This dinosaur's limbs were short, stocky, and strong. The front feet had short, sturdy toes, which helped to support the considerable body weight.

^ TAIL CLUB
The massive tail club was made of fused bones – two large and several smaller bones. This weapon was probably used in defence.

^ TAIL VERTEBRAE
About halfway along the tail, the typical tail vertebrae – armed with spikes – gave way to a fused, bony structure. This rigid structure would have supported the club at the end of the tail. The tail would have been quite muscular.

short shoulder blade

WALKING TANK >
Euoplocephalus had a wide, low-slung body, supported by short, stout limbs. In cross-section it would have been almost round. Its small head was protected at the back by spikes, and its beaked mouth would have had small, ribbed teeth adapted for munching plants.

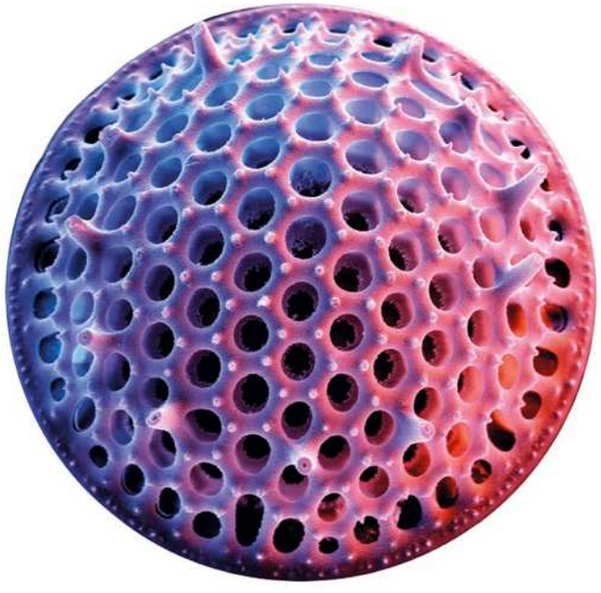
broad, rounded ribcage

in life, bony studs were covered with scaly horn

elbow joint

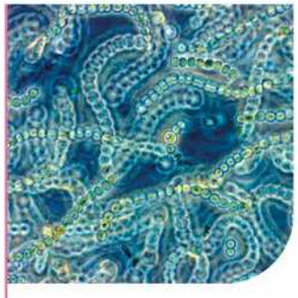
bony studs and spines along back
head spike
massive leg bones supported the weight of the armoured body
long, convoluted nasal passages inside the skull suggest this dinosaur had a keen sense of smell
hind feet had three toes, each tipped with a blunt hoof

MICROS
LIFE



COPIC

Despite their tiny size, microscopic organisms dominate life on Earth. They were the first living things to evolve, and they underpin all the world's ecosystems, capturing and releasing nutrients that other forms of life need to survive. From the simplest bacteria to the most complex protoctists, they make up a constellation of varied and versatile life forms that largely goes unseen.



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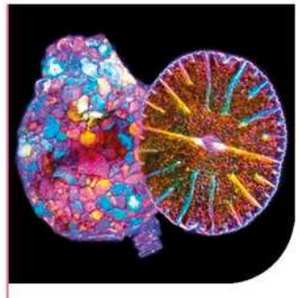
ARCHAEA AND BACTERIA

Life at its most basic, archaea and bacteria are single-celled organisms without nuclei. Most live as individuals, though some form colonies such as filaments and chains.



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PROTOCTISTS

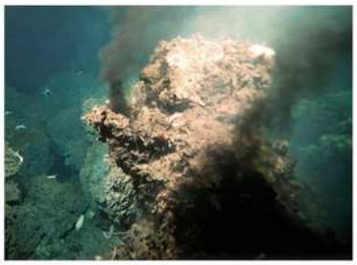
Among the most numerous living things, protoctists are also some of the most diverse. Some have no fixed shape, but many have elaborate mineral skeletons or shells. They are typically single-celled.

ARCHAEA AND BACTERIA

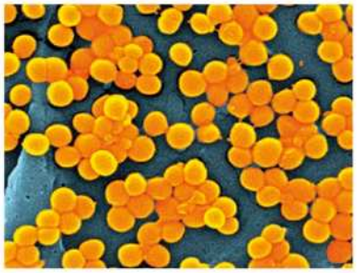
An alien visiting Earth might conclude that its true masters were the archaea and the bacteria. They outnumber, and are more diverse than, the more complex life forms known as the eukaryotes, and thrive in every nook and cranny of the planet.

DOMAIN	ARCHAEA
PHYLA	12
ORDERS	18
FAMILIES	28
SPECIES	Probably millions

DOMAIN	BACTERIA
PHYLA	About 50
ORDERS	180
FAMILIES	430
SPECIES	Probably millions



Hydrothermal vents at the bottom of oceans are home to various thermophile archaea living at high temperatures.



***Staphylococcus* bacteria** are common agents of food poisoning in humans, forming microscopic clusters in food.

DEBATE

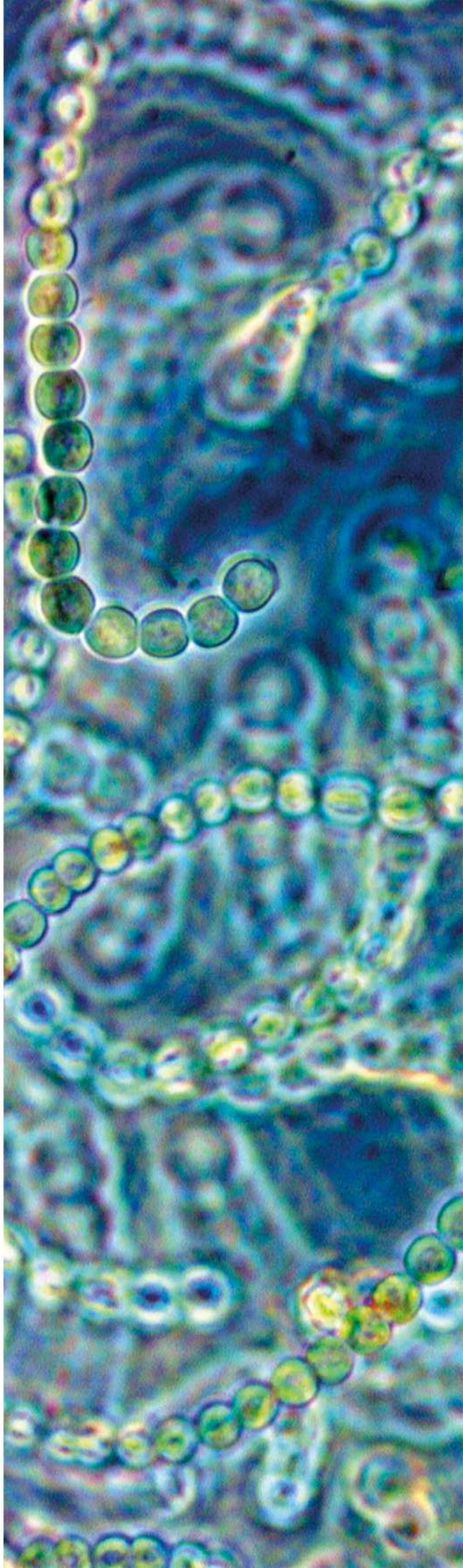
CAULDRON OF LIFE

Many archaea are adapted for extremes; in hot water their fragile DNA is lagged by protective protein. Similiar protein braces the longer chromosomes of eukaryotes (fungi, plants, and animals). So perhaps what began as insulation in primeval pools evolved into a "scaffold" for the extra DNA needed for more complex life.

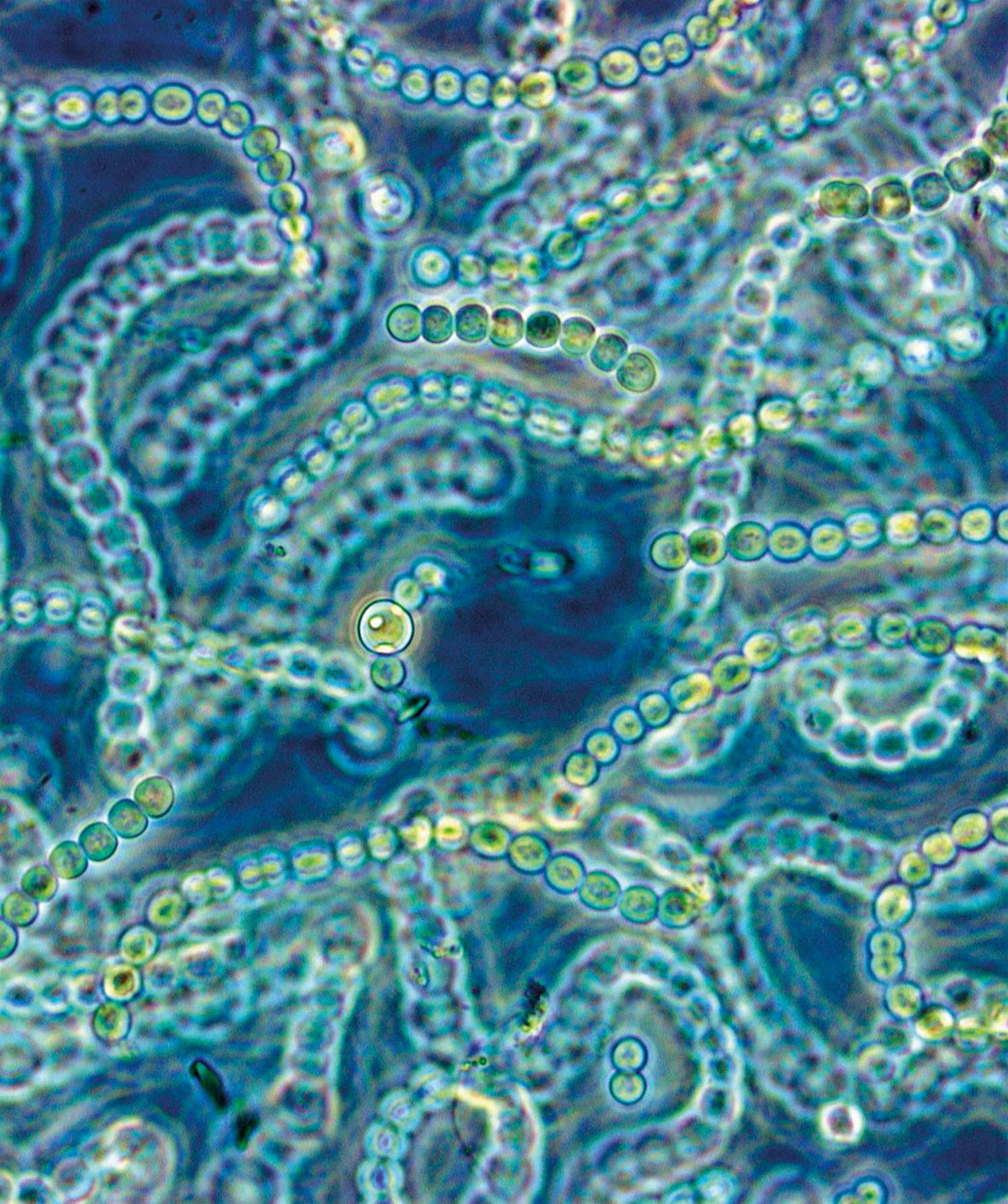
The archaea and bacteria are single-celled organisms and were the first forms of life on Earth. They form two of life's three fundamental divisions, along with the eukaryotes. While all living cells possess DNA, eukaryote cells contain it within a membrane-bound nucleus, and most also have energy-generating mitochondria. Archaea and bacteria have neither a nucleus nor mitochondria. They are only distantly related to each other, having evolved from separate, as yet unknown genetic origins. Archaea cells are contained by chemically unique membranes overlain by a tough outer cell wall, and within the cell their DNA is often protein-covered. Bacteria cells have very different physical and chemical makeups, particularly in their cell wall. Their different properties make the typical archaea especially suited to harsh habitats, while bacteria are ubiquitous and thrive in every environment.

SMALLEST LIVING THINGS

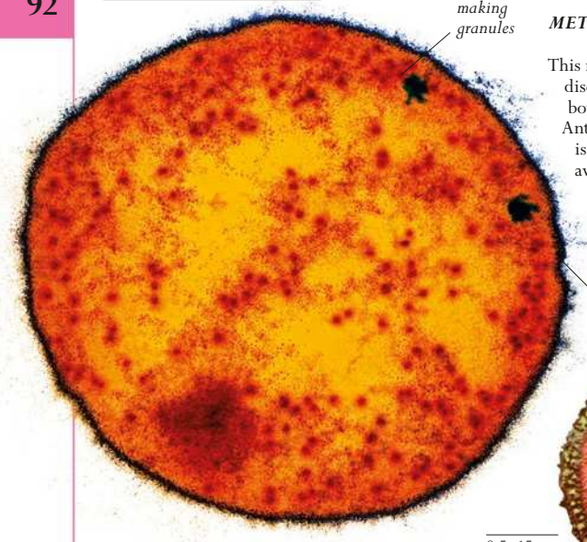
All archaea and bacteria are tiny, their size measured in microns or micrometres (µm); 1 µm equals one-thousandth of a millimetre. A human hair is about 80 µm thick; most archaea and bacteria are just 1–10 µm in length. Yet they survive in almost every corner of the biosphere, from the outer atmosphere to deep within Earth's crust, and from ocean depths to inside the human body. Some archaea and bacteria thrive in boiling water or freezing ice, survive radiation, and even live off poisonous gases and corrosive acids. Most get nourishment from dead material, others from infesting living bodies. While some make food in darkness, by using the energy in minerals, others use photosynthesis, using the energy in light to convert carbon dioxide and water into food and oxygen. Although notorious for causing infectious diseases, bacteria are actually essential to human health, with humans depending on their gut bacteria to help break down food and to manufacture essential nutrients. For almost 4 billion years, archaea and bacteria have profoundly influenced Earth's climate, rock formation, and the evolution of other forms of life.



MICROSCOPIC CYANOBACTERIA COLONY >
Although bacteria have single cells, the cells of some, such as cyanobacteria, can join together in spectacular, long filaments.

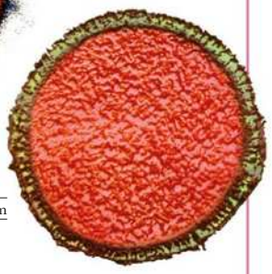


ARCHAEA



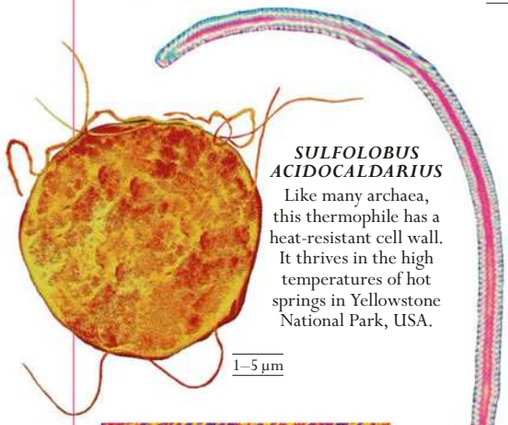
METHANOCOCCOIDES BURTONII

This methane producer was discovered living at the bottom of Ace Lake in Antarctica, where there is no oxygen and the average temperature is 0.6 °C (33 °F).



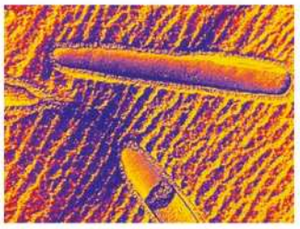
STAPHYLOTHERMUS MARINUS

Discovered in a hydrothermal vent on the sea floor, this species grows best at 85–92 °C (184–198 °F). It forms grape-like clusters, and can grow comparatively large.



SULFOLOBUS ACIDOCALDARIUS

Like many archaea, this thermophile has a heat-resistant cell wall. It thrives in the high temperatures of hot springs in Yellowstone National Park, USA.

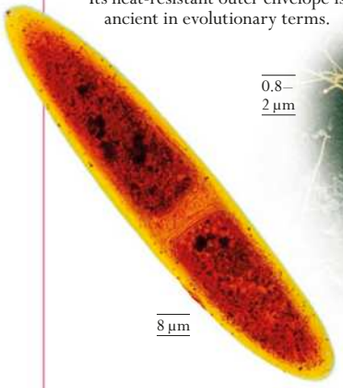


THERMOPROTEUS TENAX

This species forms rod-shaped cells of varying length but constant diameter. Its heat-resistant outer envelope is ancient in evolutionary terms.

DESULFUROCOCCUS MOBILIS

This anaerobe thrives where oxygen is limited or absent and uses sulfur-containing compounds in place of oxygen. An extreme thermophile, it grows best at 85 °C (184 °F).



METHANOSPIRILLUM HUNGATEI

Discovered in human sewage, this archaean generates large amounts of methane during sewage disposal. Each cell is confined within a hollow sheath.

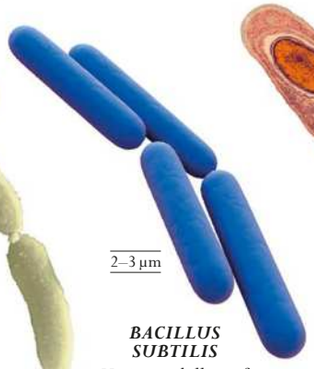
PYROCOCCUS FURIOSUS

Pyrococcus means "fireberry", reflecting this archaean's shape and its tolerance of extreme temperatures: it grows best at 100 °C (212 °F).

BACTERIA

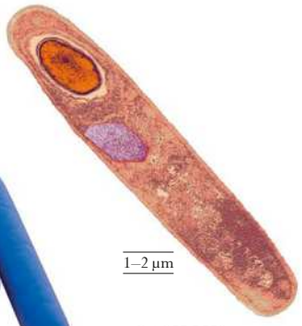
ACETOBACTER ACETI

Used to make vinegar, this species is also a common contaminant wherever alcohol is brewed, causing discoloration and souring of beer in particular.



BACILLUS SUBTILIS

Up to one billion of these bacteria can be found in a single gram of soil. When food is scarce or the environment becomes harsh it can live as an inactive spore.

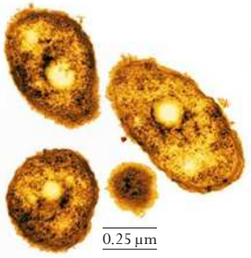


BACILLUS THURINGIENSIS

This bacterium produces toxic crystals insoluble in the human gut but lethal to insects, and is therefore commercially marketed as an insecticide.

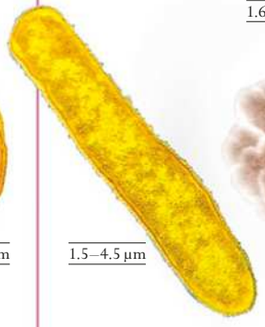
DEINOCOCCUS RADIODURANS

This species is known as the world's toughest bacterium. It was discovered in meat that had been exposed to doses of radiation in an experiment.



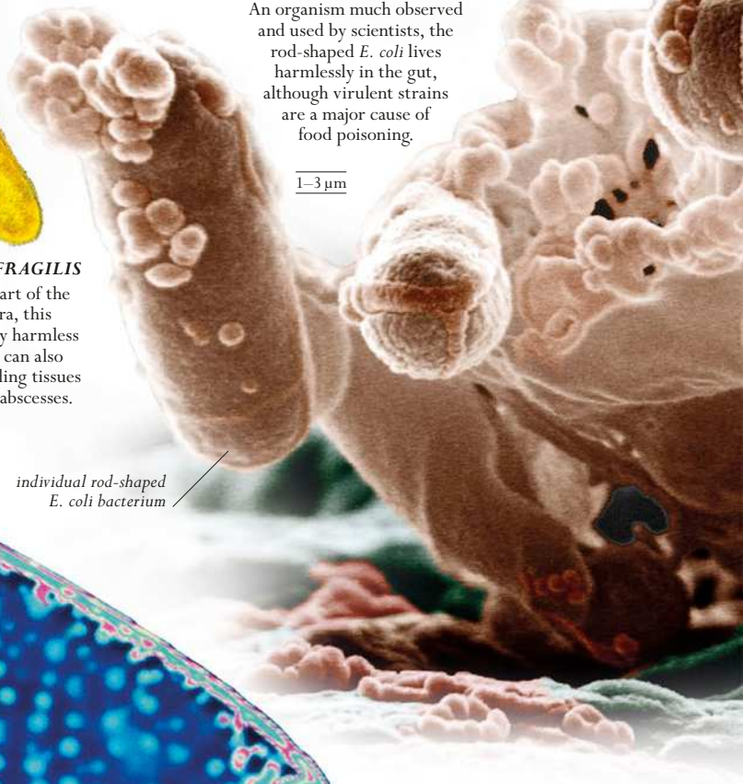
BORDETELLA PERTUSSIS

This species causes whooping cough, or pertussis, a respiratory infection marked by severe, spasmodic coughing episodes, and breakdown of blood cells.



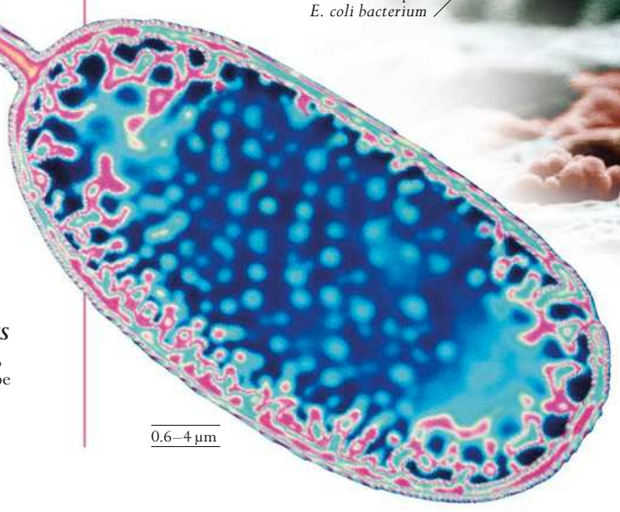
BACTEROIDES FRAGILIS

Forming a large part of the human gut's flora, this bacterium is usually harmless to its host. But it can also cause disease, invading tissues to form pus-filled abscesses.



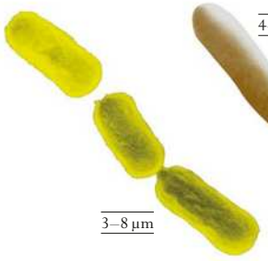
ESCHERICHIA COLI

An organism much observed and used by scientists, the rod-shaped *E. coli* lives harmlessly in the gut, although virulent strains are a major cause of food poisoning.



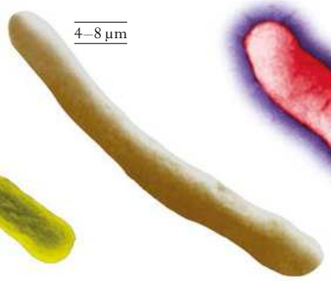
***NITROBACTER* SP.**

This genus of bacteria plays a role in the nitrogen cycle by oxidizing nitrites into nitrates. This helps purify water and is central to fertilizing the oceans and the soil.



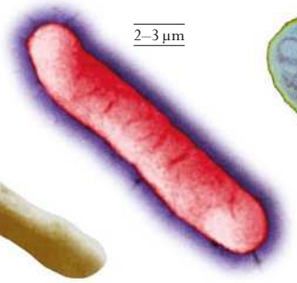
CLOSTRIDIUM BOTULINUM

This bacterium thrives where oxygen is limited or absent. Living in soil, it produces the neurotoxins that cause botulism, but which also have medical and cosmetic uses.



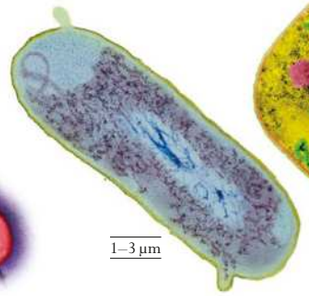
CLOSTRIDIUM TETANI

A soil organism that can grow in dead tissue in wounds or burns, *C. tetani* produces tetanospasmin, the neurotoxin that causes tetanus.



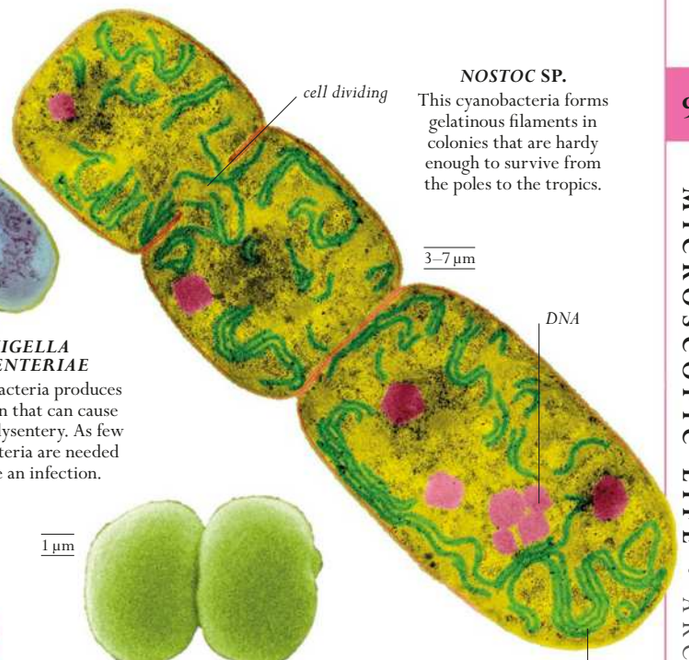
SALMONELLA ENTERICA

Belonging to the same family as *E. coli*, some subspecies of *Salmonella* bacteria cause gastroenteritis; others cause typhoid fever.



SHIGELLA DYSENTERIAE

This gut bacteria produces shiga toxin that can cause epidemic dysentery. As few as ten bacteria are needed to cause an infection.

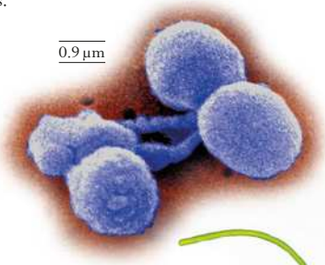


NOSTOC SP.

This cyanobacteria forms gelatinous filaments in colonies that are hardy enough to survive from the poles to the tropics.

STREPTOCOCCUS PNEUMONIAE

This bacterium, present inside humans, can cause pneumonia. In children and the elderly, it is the leading cause of invasive infection that moves into all parts of the body.

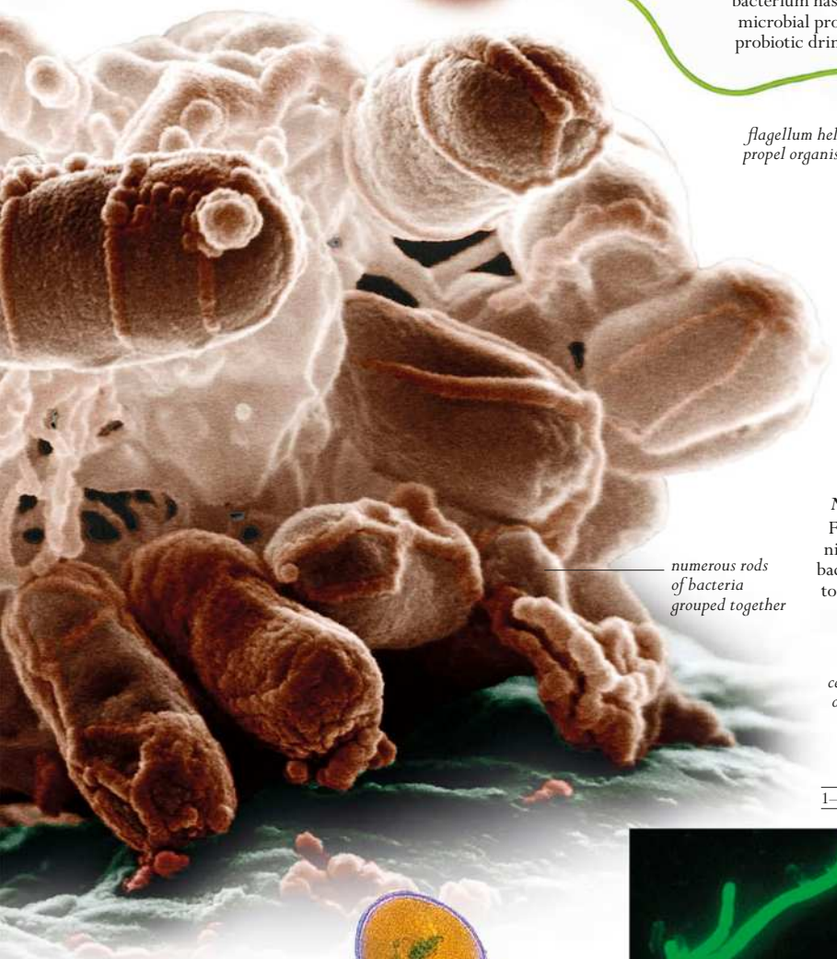


LACTOBACILLUS ACIDOPHILUS

Found in the intestine and vagina, this bacterium has nutritional and anti-microbial properties. It is used in probiotic drinks and supplements.

STAPHYLOCOCCUS EPIDERMIDIS

This spherical bacterium can be found on the skin as part of normal flora, but can cause infections in immune-compromised patients.

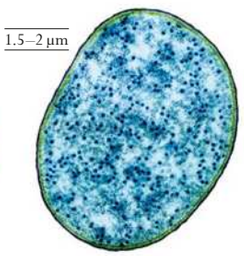


VIBRIO CHOLERAE

Highly mobile curved rods with a single flagellum at one end, this species secretes a potent enterotoxin that causes cholera.

FUSOBACTERIUM NUCLEATUM

This species makes its home in the human mouth, and forms a major component of plaque. It can also cause premature birth.

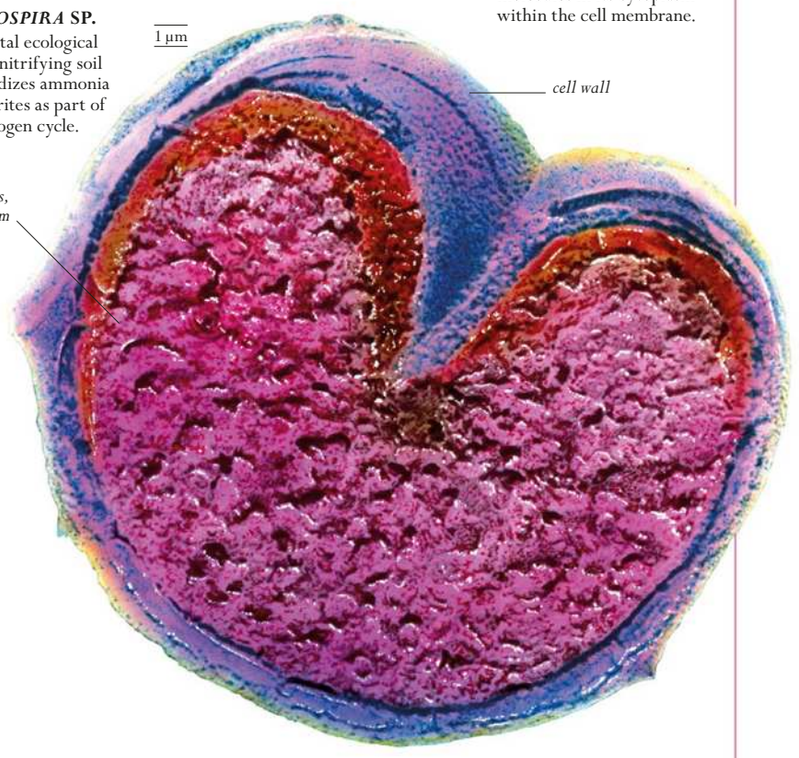


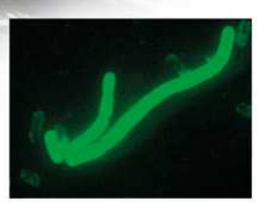
PSYCHROBACTER URATIVORANS

This species is a psychrophile, or cryophile, which means it thrives at very low temperatures, thanks to natural antifreeze molecules in its cytoplasm within the cell membrane.

NITROSOSPIRA SP.

Filling a vital ecological niche, this nitrifying soil bacteria oxidizes ammonia to form nitrites as part of the nitrogen cycle.





YERSINIA PESTIS

This species is the agent that causes bubonic plague. Transmitted to humans via fleas that live on rats, it causes up to 3,000 cases worldwide each year.

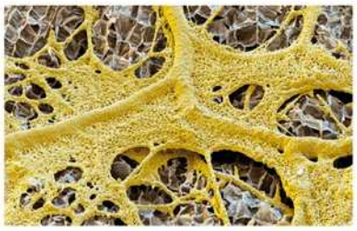
ENTEROCOCCUS FAECALIS

Normally a harmless inhabitant of the human digestive tract and vagina, this species can invade wounds and is resistant to many antibiotics.

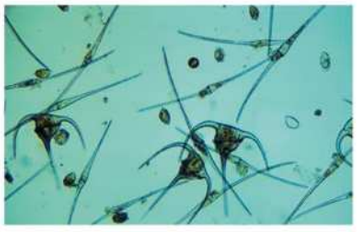
PROTOCTISTS

From tiny amoebas to giant kelp, the protoctists defy simple description, yet this informal grouping of eukaryotes included the first life forms to evolve that were more complex than the archaea and bacteria. It still produces most of Earth's food and oxygen.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADES AND DIVISIONS	More than 9
FAMILIES	About 841
SPECIES	About 73,500



In some slime moulds, which are a group of amoebas, thousands of individual nuclei coexist within one giant cell.



Many single-celled protoctists have extraordinary shapes, such as these grapple-like dinoflagellates.

Some protoctists cause devastating disease, such as this *Giardia*, which infects intestines of humans and other animals.

DEBATE

MULTIPLE KINGDOMS

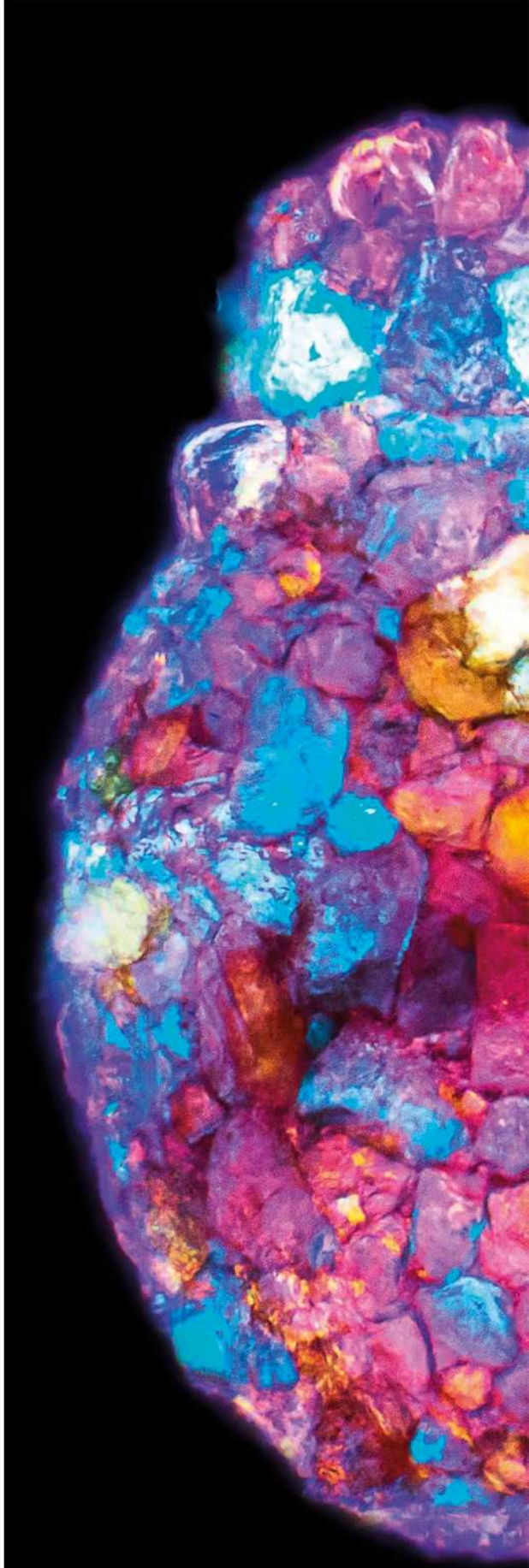
The kingdom Protoctista includes many organisms that are not classified as fungi, plants, or animals. And it includes many groups, ranging from single-celled amoebas to multicellular seaweeds, that are not closely related to one another. Many scientists think that Protoctista should be split into more than one kingdom.

Protoctists are mainly single-celled creatures that, unlike archaea and bacteria, have cell nuclei. Their basic cell nature separates them from the higher eukaryotes – plants, fungi, and animals – that later emerged from them. The protoctists include an incredible range of organisms with diverse lifestyles and ecological niches. Most are microscopic, ranging in size from 10 to 100 µm, and some are tiny enough to infest red blood cells. Others, however, are multicellular organisms such as kelp, a seaweed that grows up to tens of metres in length, or the strange, fungus-like slime moulds, which form creeping puddles of slime that are essentially one giant cell. Typical protoctists include amoebas, which move about and capture food particles with their pseudopods (cell extensions), or plankton drifting in the sea, such as the beautiful diatoms, which have intricate silicon-based skeletons.

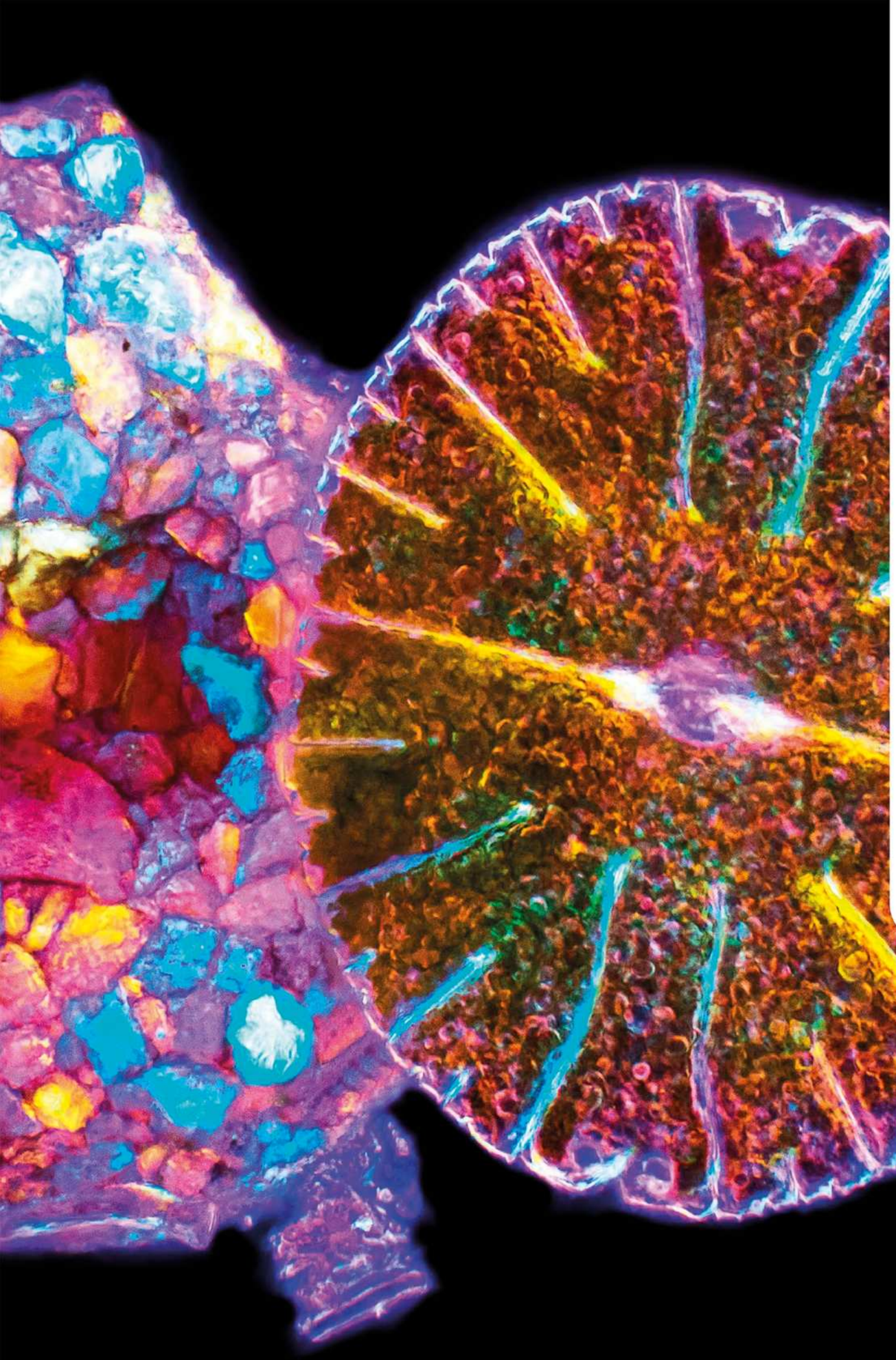
A HIDDEN REALM OF LIFE

Protoctists are among the most numerous creatures on Earth. Vast numbers of them live in the oceans and rivers, in sediments at the bottom of seas and lakes, and in the soil, while many spend all or part of their life cycles as parasites inside other organisms. They play a vital role in the planet's ecosphere, in particular as primary photosynthesizers, using the energy in light to convert carbon dioxide and water into food, while releasing oxygen into the atmosphere. They also act as predators and recyclers of matter. A few species are well known because they cause major diseases: the parasitic *Plasmodium* causes malaria, one of the biggest killers of humans; another parasite, *Trypanosoma brucei*, causes sleeping sickness. Also familiar are the dinoflagellates, a group of plankton organisms that can cause "red tides" – huge blooms of toxic creatures that kill fish and poison humans.

The taxonomy of the protoctists is complex as they don't form a natural kingdom. However, molecular and genetic analysis has allowed most protoctists to be placed in a few large clades, groups that each share a common ancestor, such as the Amoebozoa, Rhizaria, and Alveolata. The red algae, green algae, and the stoneworts each have their own division.



SMALL WONDERS >
This polarized light micrograph reveals an *Arcella* shelled amoeba and a *Micrasterias* desmid in all their beauty.



PROTOCTIST GROUPS

The taxonomic groupings for the protoctists, which can be difficult to order, are new and evolving and can be subject to argument. The latest thinking is set out here.

AMOEBAS AND RELATIVES
» 96

FLAGELLATES
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RHIZARIANS
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HETEROKONTS
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RED ALGAE
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GREEN ALGAE
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STONEWORTS AND RELATIVES
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AMOEBAS AND RELATIVES

Two of the protoctist clades, the Amoebozoa and the Opisthokonta, have evolved different ways of moving about and obtaining food.

Amoebas of the clade Amoebozoa can change shape by oozing projections, called pseudopods, of their single cells. They use these "false feet" to creep forward and hunt smaller organisms, enveloping victims within a sac of fluid and digesting them while still alive. Some amoebas are giant cells, and are just visible to the naked eye. A few are gut parasites, causing amoebic dysentery in humans. One group, the slime moulds, have a remarkable strategy for avoiding starvation. When prey runs low their cells are attracted to one another by a chemical distress signal, and aggregate into a tiny creeping slug. This then sprouts upward a number of stalks, which burst to scatter spores. Each spore hatches into a new amoeba ready to hunt on new ground.

ANIMAL-FUNGUS ORIGINS

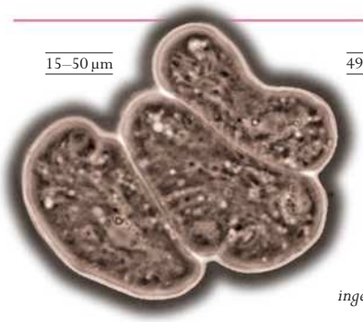
Most protoctists of the clade Opisthokonta have developed a single whip-like flagellum for propulsion in open water. Early in the history of life, some of these protoctists may have given rise to animals, and the single flagellum is still seen in the tail of animal sperm today. Others, called nucleariids, lost their flagellum and actually reverted to the amoeba-like state. The nucleariids may be closely related to fungi, as fungi also lack flagella and fertilize one another without the involvement of free-swimming sperm.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADES	2
FAMILIES	About 50
SPECIES	About 4,000

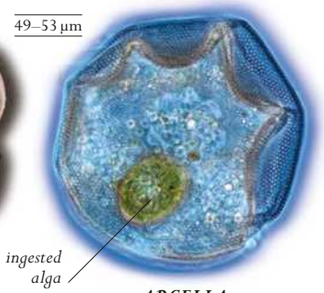
DEBATE

LIFE'S FIRST BRANCHES?

One theory of evolution says that the eukaryotes divided into two branches: unikonts (cells with one flagellum), such as opisthokonts, and bikonts (cells with two). Unikonts evolved into animals and fungi, while bikonts gave rise to plants. However, the DNA evidence for the theory is equivocal.



DYSENTERY AMOEBA
Entamoeba histolytica
This parasitic amoeba lives in the human intestine and can cause amoebic dysentery. It can contain up to eight nuclei.

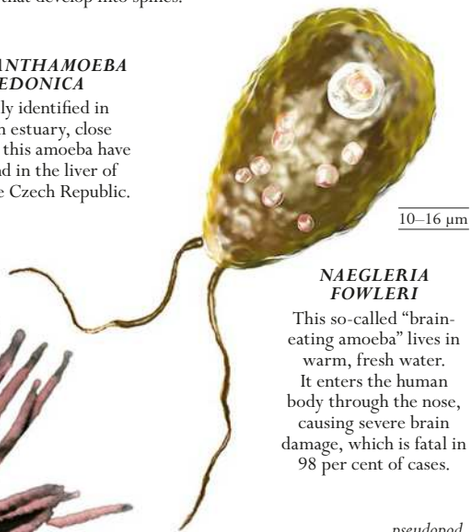


ARCELLA BATHYSTOMA
This amoeba has a circular shell pitted with pores, domed on one side but sometimes with angular facets that develop into spines.

ARCELLA VULGARIS
Mainly found in stagnant water and soil, this amoeba has a convex shell, with a hole that allows pseudopods to emerge.

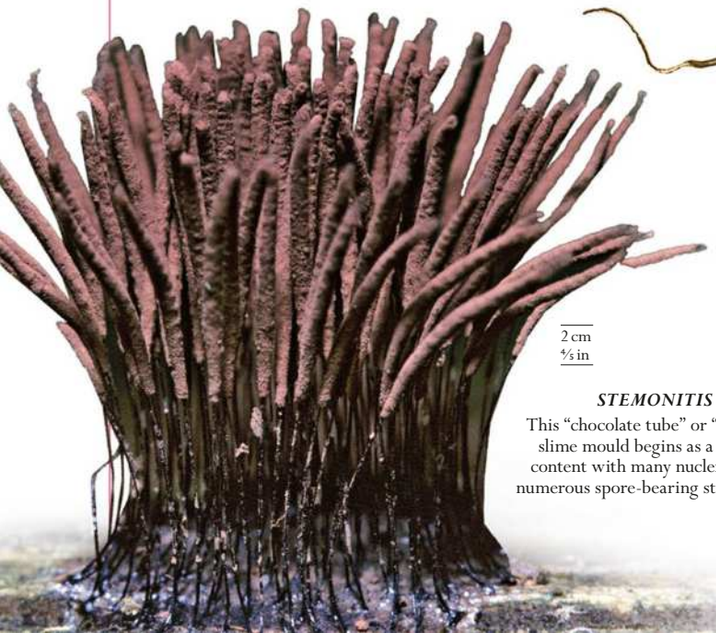
ARCELLA DISCOIDES
This amoeba with two nuclei has a yellow-brown shell with a hole on one side through which pseudopods emerge.

PROTACANTHAMOEBA CALEDONICA
Originally identified in a Scottish estuary, close relations of this amoeba have been found in the liver of tench in the Czech Republic.

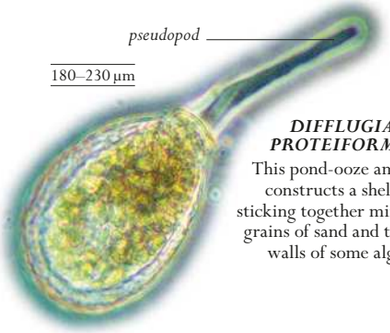


NAEGLERIA FOWLERI
This so-called "brain-eating amoeba" lives in warm, fresh water. It enters the human body through the nose, causing severe brain damage, which is fatal in 98 per cent of cases.

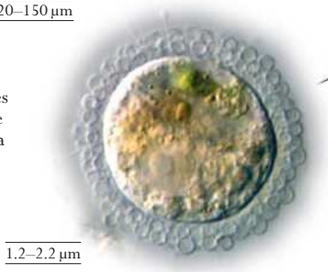
CENTROPYXIS ACULEATA
This amoeba lives on algae in lakes and marshes. It uses sand and the cell walls of some algae to make a shell with four to six spines.



***STEMONITIS* SP.**
This "chocolate tube" or "pipe cleaner" slime mould begins as a mass of cell content with many nuclei from which numerous spore-bearing stalks sprout up.



DIFFLUGIA PROTEIFORMIS
This pond-ooze amoeba constructs a shell by sticking together minuscule grains of sand and the cell walls of some algae.



SCALY NUCLEARIID
Pompholyxophrys ovuligera
Once assigned to the heliozoans clade, this flagellate of the Opisthokonta is covered in hollow scales or beads.

FLAGELLATES

The whip-like propulsion of single-celled organisms has evolved in several groups of protoctists, some unrelated. But it predominates in the Excavata.

Flagellates are powerful swimming microbes that move by the whip-like action of one or more external threads called flagella. Many are predators, preying on smaller organisms such as bacteria. However, unlike changeable amoebas, these flagellates have a fixed, rigid shape and direct food into a cellular "mouth" at the base of the flagella. Remarkably, however, some, such as *Euglena*, have a degree of behavioural versatility that provides them with plant- and animal-type nutrition, depending upon circumstance. When exposed to bright light these organisms can photosynthesize; but in darkness their light-absorbing cell organelles, known as chloroplasts, shrivel and they revert to being a predator.

LIVING INSIDE ANIMALS

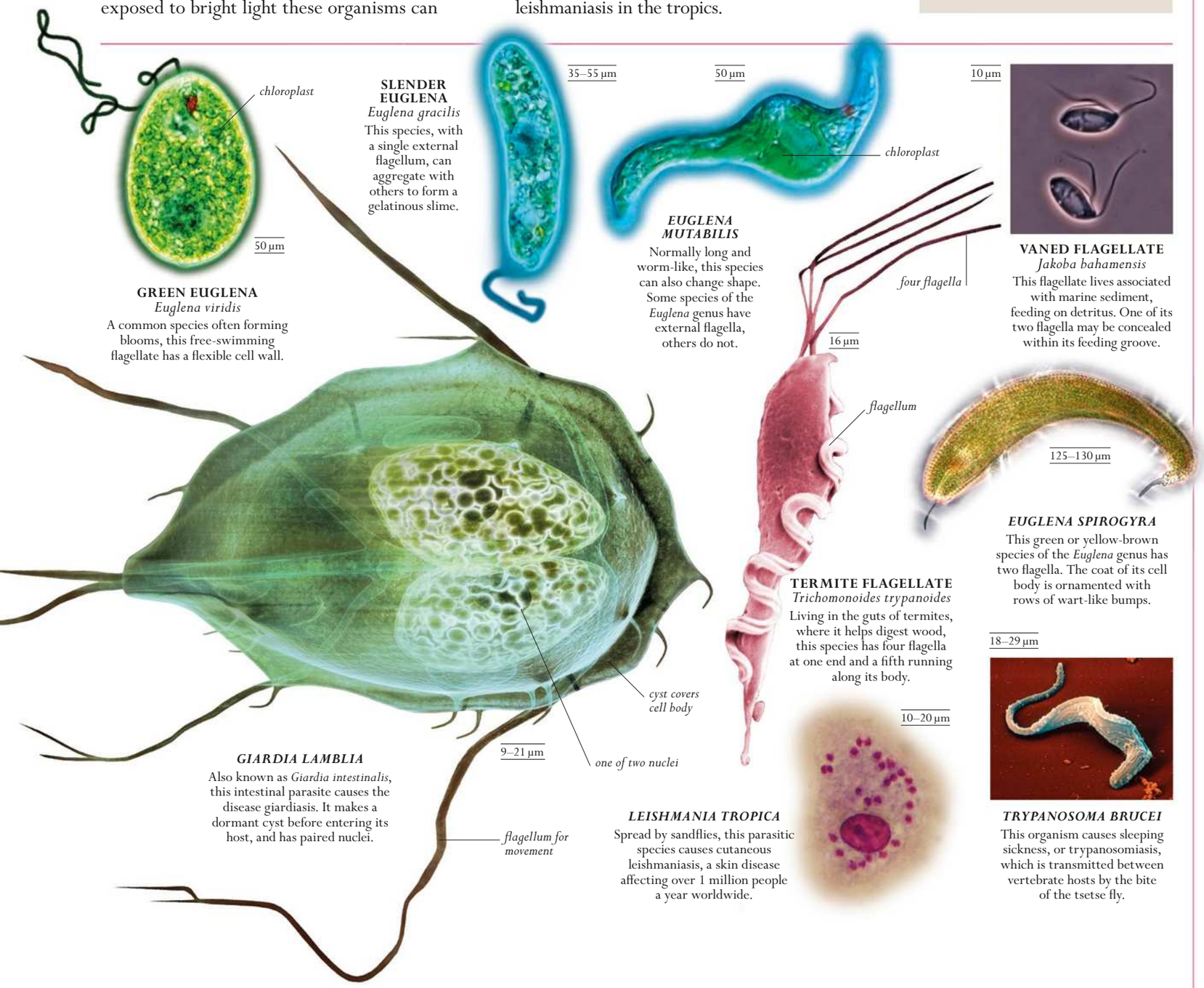
Many flagellates of this group lack the ordinary cellular features that would enable them to use oxygen in their respiration and survive inside the oxygen-poor environment of animal guts. Many are extraordinarily specialized, subsisting on the partially-digested food inside the abdomens of insects, but causing their host no harm. Others are parasites that cause devastating disease, including in humans. One notorious group, the trypanosomes, are transmitted by biting insects and are responsible for sleeping sickness and leishmaniasis in the tropics.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADE	EXCAVATA
FAMILIES	40
SPECIES	About 2,500

DEBATE

EVOLUTION DOWN-SIZING

The flagellates inside termite guts lack mitochondria, the cell organelles most other protoctists use to respire with oxygen. Some think these flagellates are primitive protoctists. Others say they are more advanced organisms, and lost their mitochondria by evolving in an oxygen-poor environment.



GREEN EUGLENA
Euglena viridis
A common species often forming blooms, this free-swimming flagellate has a flexible cell wall.

SLENDER EUGLENA
Euglena gracilis
This species, with a single external flagellum, can aggregate with others to form a gelatinous slime.

EUGLENA MUTABILIS
Normally long and worm-like, this species can also change shape. Some species of the *Euglena* genus have external flagella, others do not.

VANED FLAGELLATE
Jakoba bahamensis
This flagellate lives associated with marine sediment, feeding on detritus. One of its two flagella may be concealed within its feeding groove.

EUGLENA SPIROGYRA
This green or yellow-brown species of the *Euglena* genus has two flagella. The coat of its cell body is ornamented with rows of wart-like bumps.

TERMITE FLAGELLATE
Trichomonoides trypanoides
Living in the guts of termites, where it helps digest wood, this species has four flagella at one end and a fifth running along its body.

GIARDIA LAMBLIA
Also known as *Giardia intestinalis*, this intestinal parasite causes the disease giardiasis. It makes a dormant cyst before entering its host, and has paired nuclei.

LEISHMANIA TROPICA
Spread by sandflies, this parasitic species causes cutaneous leishmaniasis, a skin disease affecting over 1 million people a year worldwide.

TRYPANOSOMA BRUCEI
This organism causes sleeping sickness, or trypanosomiasis, which is transmitted between vertebrate hosts by the bite of the tsetse fly.

RHIZARIANS

The clade Rhizaria includes two phyla that are among the most beautiful of all of the miniature protoctists: the radiolarians and the forams.

The unique, intricately sculptured shells of both phyla make them distinctive members of the microscopic world, and some have left an impressive fossil record. Most radiolarians build a glassy shell with silica, stripping the ocean surface of this otherwise abundant mineral when they bloom in large numbers. Their body radiates long pseudopods that poke through their shell like the rays of the sun, supplemented in some by hardened spines. Radiolarians use their pseudopods for catching food, but some also harbour living algae, gaining nourishment from the sugars their photosynthetic partners make as they drift in sunlit tropical oceans. Their silica dependence binds radiolarians to the sea, but their allies, the cercozoans, have also exploited soil and fresh water. Cercozoans typically retain the long pseudopods, but have shelled, and shell-less forms, and some have flagella, depending on habitat demands.

The forams, or foraminiferans, have flourished in the oceans for hundreds of millions of years and their calcium carbonate shells litter the seabed to form layers of chalky sediment. Foram shells are so distinctive, even when fossilized, that geologists can use them to date deposits and identify hidden reservoirs of oil. When alive, each shell harbours a tiny amoeba that hunts with pseudopods – like the radiolarians – although some are big enough to catch animal larvae.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADE	RHIZARIA
FAMILIES	108
SPECIES	About 14,000

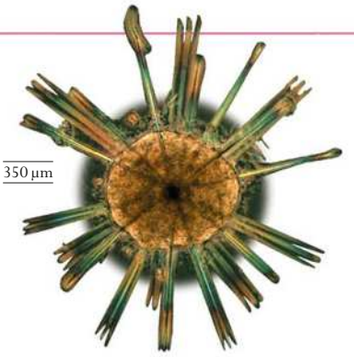
DEBATE

CONVERGING GIANTS

The pseudopods of radiolarians and forams enmesh to form nets around their cells. This perhaps supports the idea that both forms descend from a common ancestor. But it is possible that this net evolved independently in the two groups, perhaps a result of both having large single cells.

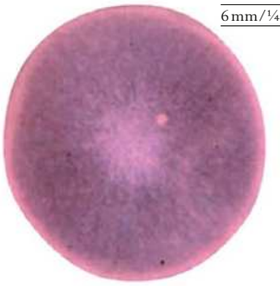
LATTICE-SHELLED RADIOLARIAN
This radiolarian species of plankton belongs to the Spumellaria order, most of which have silica latticework skeletons.

100 µm



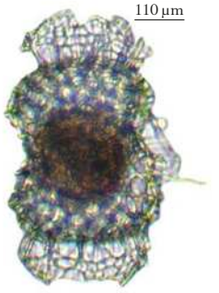
350 µm

STAR RADIOLARIAN
Astrolithium sp.
In this radiolarian, the bases of the radial spines are fused into a star-shaped mass, or central body.



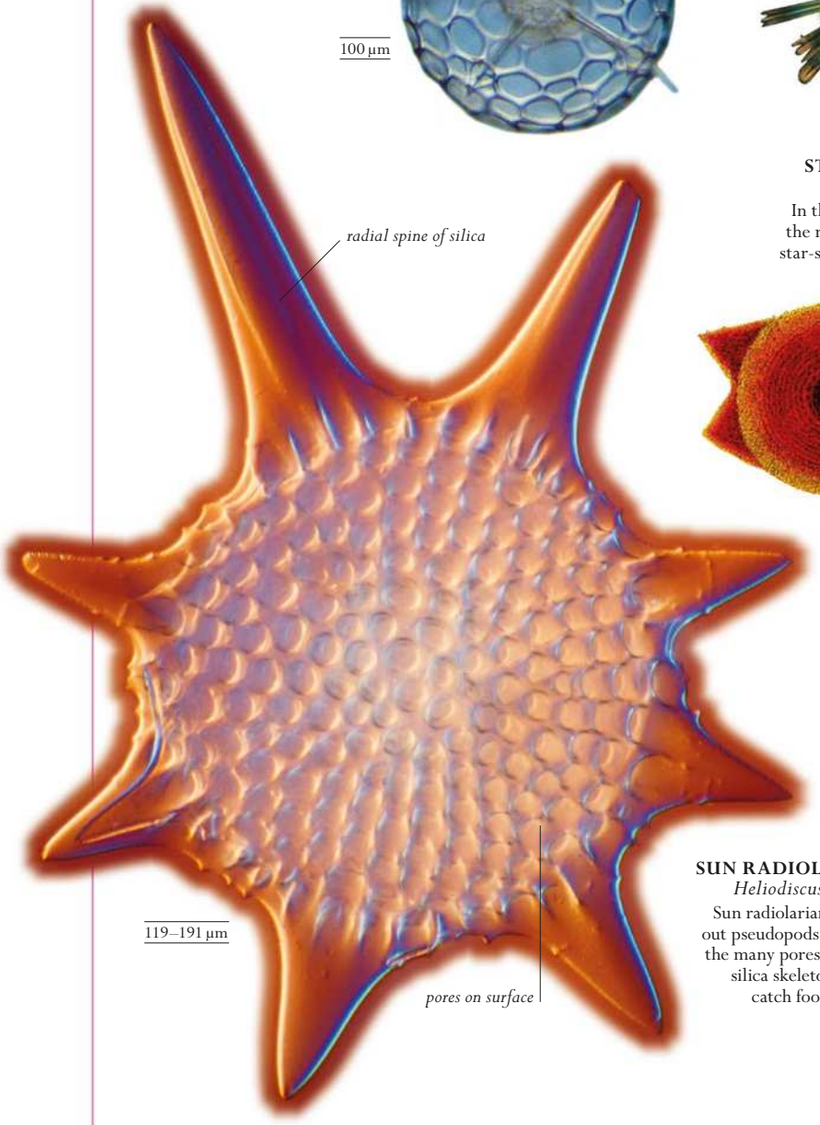
6 mm/¼ in

SPHERICAL RADIOLARIAN
Physematium sp.
The cell surface of this species holds photosynthesizing organisms in a mesh of thin pseudopods.



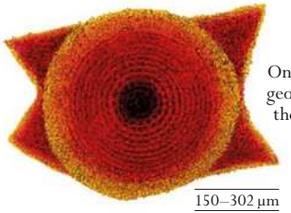
110 µm

DIDYMOCYRTIS TETRATHALAMUS
A living representative of an ancient fossil lineage, this radiolarian is named for its twin shells, which sometimes have hemispherical or conical caps.



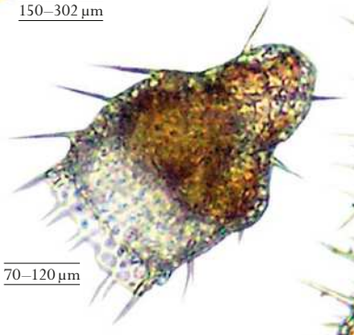
119–191 µm

SUN RADIOLARIAN
Heliodiscus sp.
Sun radiolarians send out pseudopods through the many pores in their silica skeleton to catch food.



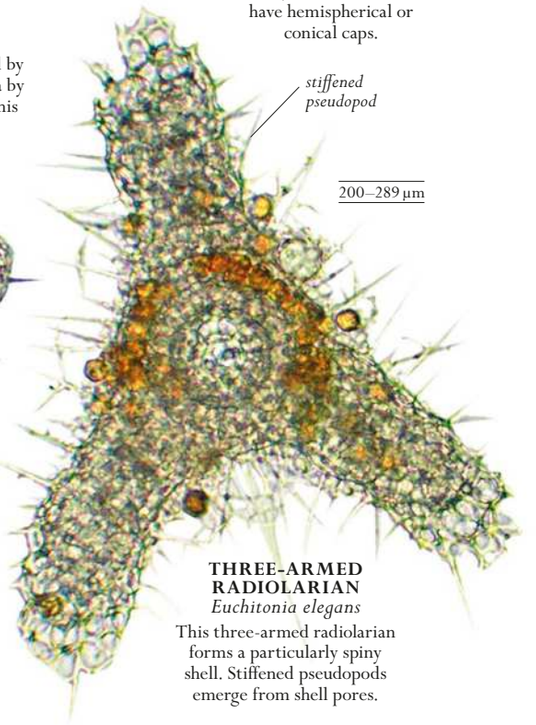
150–302 µm

SPONGASTERICUS QUADRICORNIS
One of the radiolarians used by geologists to help date strata by the presence of its fossils, this species' name means "four-cornered".



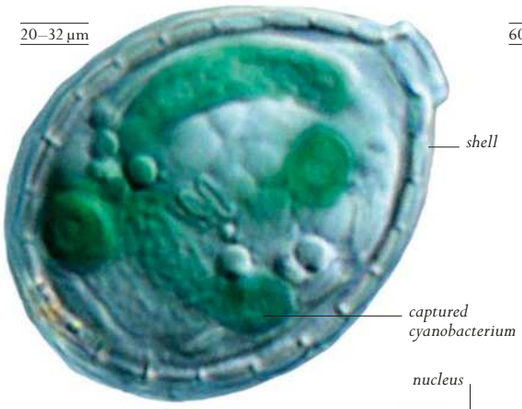
70–120 µm

SPINY RADIOLARIAN
Lithomelissa setosa
This species displays the greatest seasonal variation of any radiolarian, making it a useful seasonal indicator in fossil and sedimentary records.

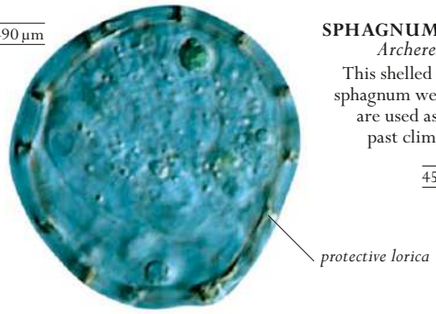


200–289 µm

THREE-ARMED RADIOLARIAN
Euchitonia elegans
This three-armed radiolarian forms a particularly spiny shell. Stiffened pseudopods emerge from shell pores.

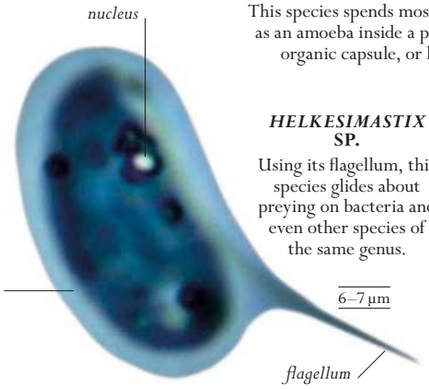


OVAL-GREEN CERCOZOAN
Paulinella chromatophora
This freshwater shelled amoeba contains living cyanobacteria that can photosynthesize, providing the amoeba with food.



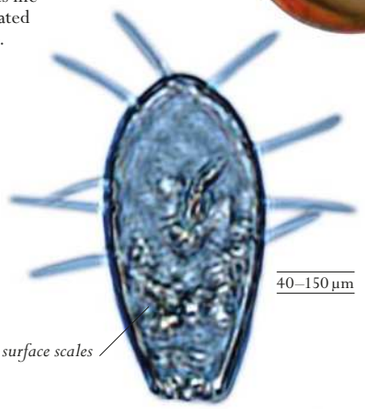
ELEGANT CERCOZOAN
Clathrulina elegans
This species spends most of its life as an amoeba inside a perforated organic capsule, or lorica.

SPHAGNUM CERCOZOAN
Archerella flavum
This shelled amoeba lives in sphagnum wetlands. Its fossils are used as indicators of past climate changes.

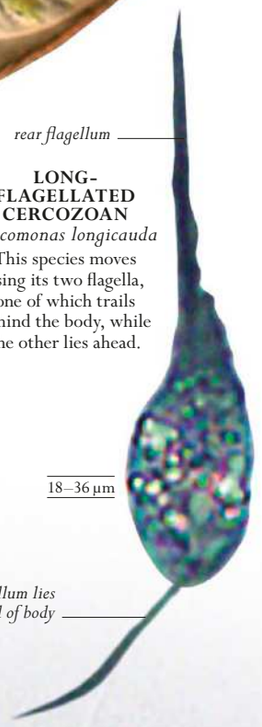


***HELKESIMASTIX* SP.**
Using its flagellum, this species glides about preying on bacteria and even other species of the same genus.

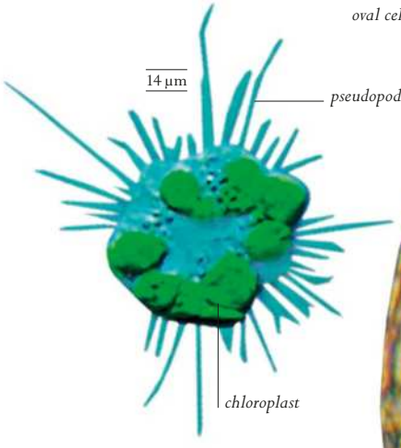
6–7 µm



SCALY CERCOZOAN
Euglypha sp.
This amoeba constructs oval-shaped shells from thin scales of silica, which fossilize well, making them objects of study for micropaleontologists.



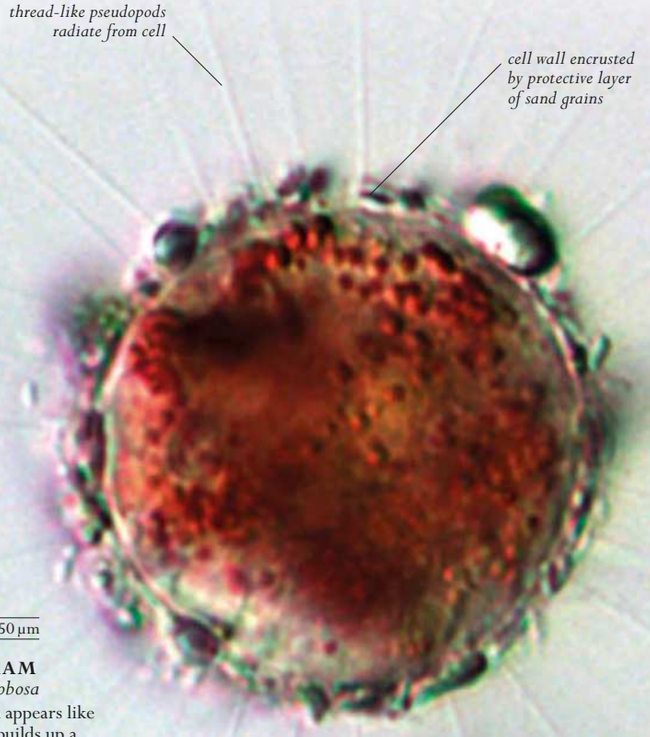
LONG-FLAGELLATED CERCOZOAN
Cercomonas longicauda
This species moves using its two flagella, one of which trails behind the body, while the other lies ahead.



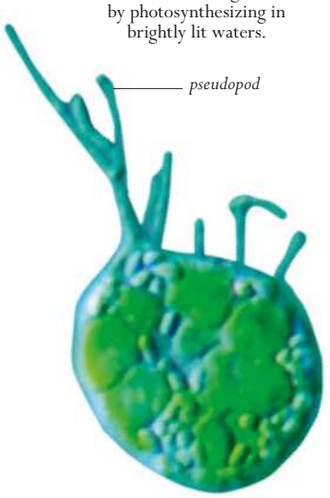
GYMNOCHLORA STELLATA
Unlike many cercozoans, this species contains chloroplasts, which enable it to gain food by photosynthesizing in brightly lit waters.

OVAL-SHELLED CERCOZOAN
Trinema sp.
This shell of this amoeba is open at one end, creating a type of mouth.

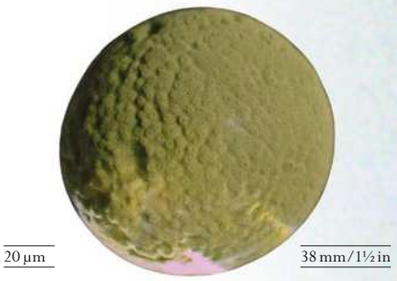
YELLOW-SHELLED CERCOZOAN
Cyphoderia ampulla
This amoeba has a colourless or yellow shell composed of disc-shaped scales.



SAND FORAM
Lithocolla globosa
This species of foram appears like a radiating sun. It builds up a protective layer of sand grains and other granules on the outside of its cell wall.



MARINE-GREEN CERCOZOAN
Chlorarachnion reptans
This species contains characteristic cell organelles, which are tiny relics of a green alga it ingested in its early evolution.



GIANT CERCOZOAN
Gromia sphaerica
This species of cercozoan lives at the bottom of the ocean at the boundary between sea water and sediment. It feeds on organic detritus.

ALVEOLATES

Alveolates are united by possession of the same anatomical quirk – a fringe of tiny sacs around the cell called alveoli, after which the clade is named.

Three groups of superficially different but still single-celled protoctists are included in the alveolates: the dinoflagellates, the ciliates, and the apicomplexans. Predatory dinoflagellates live in the ocean, most using two whip-like flagella that emerge from grooves in their cell coat at right angles to one another to swim. Some can discharge stinging barbs to immobilize their prey. Others release poisons, and sudden blooms of dinoflagellates are responsible for toxic red tides in parts of the world. A few are bioluminescent, sparkling with light when disturbed at night.

Most ciliates feed on smaller organisms. Their smooth graceful motion is due to the coordinated beating of countless tiny hairs called cilia, which can cover their entire single-celled body. They also use these cilia to waft their food into a furrow that approximates to a mouth. Ciliates are virtually ubiquitous; some even live in the stomachs of mammalian herbivores, where they help in digesting the tough cellulose in plants.

In contrast, all apicomplexans are parasites. They are named for an arrangement of structures, called the apical complex, which helps them penetrate the living cells of animals, from which they derive their nourishment. Infamous among the apicomplexans are the malaria parasites, which penetrate the red blood cells of animals for food, destroying the cells in the process.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADE	ALVEOLATA
FAMILIES	222
SPECIES	About 20,000

DEBATE

PROTOZOANS

Early classifications placed food-eating microbes into different classes of the animal phylum Protozoa. Some microbes, such as the ciliates and the dinoflagellates, are now grouped together in modern protoctist taxonomy, although the exact nature of their relationships is debatable.

50–160 µm

STALKED CILIATE
Vorticella sp.
This organism has an inverted bell-shaped body on a stalk, which is known to coil like a spring when stimulated.

2–3 mm/1/10 in

TRUMPET CILIATE
Stentor muelleri
This algae-feeding species, with a horn-shaped cell body, is large for a single-celled organism.

35–90 µm

SOIL CILIATE
Colpoda inflata
This normally kidney-shaped species plays an important role in soil ecology but is vulnerable to pesticides.

40–110 µm

POND CILIATE
Colpoda cucullus
Usually found in fresh water among decaying plants, this ciliate has food-containing organelles called vacuoles within its cell.

50–130 µm

GUT CILIATE
Balantidium coli
This is the only ciliate known to parasitize humans. Infection can cause intestinal ulcers, or serious intestinal infections.

6 µm

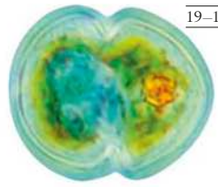
TOXOPLASMA GONDII
Passing between cats and other mammals (including humans), this apicomplexan causes the disease toxoplasmosis, which is dangerous to the unborn child in pregnancy.

225 µm

THREE-HORNED DINOFLAGELLATE
Tripos muelleri
Formerly known as *Ceratium tripos* and among the most distinctive dinoflagellates, blooms of this plankton can cause dangerous red tides.

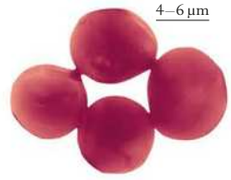
38–50 µm

CHAIN-FORMING DINOFLAGELLATE
Gymnodinium catenatum
This species of dinoflagellate forms long, swimming chains of up to 32 cells.



19–17 µm

MAHOGANY-TIDE DINOFLAGELLATE
Karlodinium veneficum
This dinoflagellate plankton can undergo a population explosion leading to "mahogany tides" that are lethal to fish.

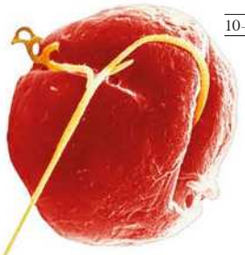


4–6 µm

CRYPTOSPORIDIUM PARVUM
This apicomplexan can cause cryptosporidiosis, a diarrhoeal disease transmitted by ingestion of its spores via faeces, usually in contaminated water.

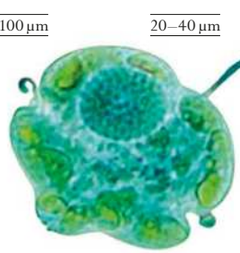
9–14 µm

PLASMODIUM FALCIPARUM
The most deadly of the malaria-causing *Plasmodium* species, this apicomplexan parasite is responsible for the deaths of over 1 million people a year worldwide.



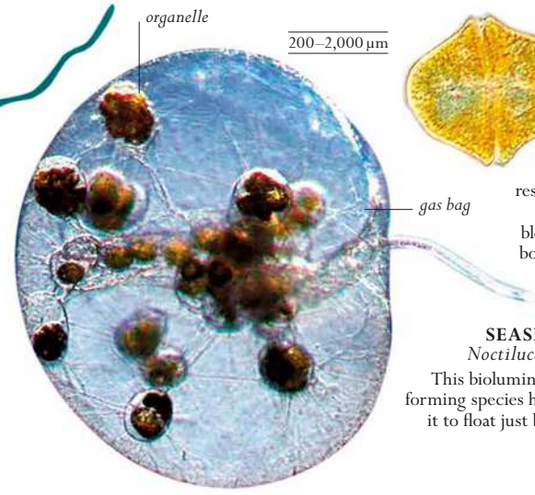
10–100 µm

***GYMNODINIUM* SP.**
Producing a neurotoxin, blooms of this dinoflagellate, found in both fresh and salt water, cause red tides and shellfish poisoning.



20–40 µm

KARENIA BREVIS
Formerly known as *Gymnodinium brevis*, this dinoflagellate plankton is a major cause of red tides in the Gulf of Mexico.



SEASPARKLE
Noctiluca scintillans
This bioluminescent, plankton-forming species has a gas bag allowing it to float just below the surface.

40–74 µm

AKASHIWO SANGUINEA
A large pentagonal species responsible for several recorded instances of harmful algal blooms, this dinoflagellate can both photosynthesize and prey on other plankton.

11–24 µm

AMPHIDINIUM CARTERAE
This plankton-forming species causes ciguatera, a fish poisoning that can cause human fatalities if contaminated fish are consumed.

HETEROKONTS

Heterokonts include some types of algae, which are photosynthesizing protoctists growing in or near water that do not have true leaves or roots.

Heterokonts are mostly defined as having two different types of flagella on the sperm they use in reproduction. One flagellum is covered in tiny, bristly hairs, or mastigonemes, and the other is smooth and whip-like. Heterokonts include diatoms and brown algae, as well as water moulds. Diatoms are single-celled algae with finely sculptured silica walls divided into two parts called valves. They are the dominant eukaryotic phytoplankton – plankton communities of small organisms that drift in open waters and engage in photosynthesis. Here, near the surface, their pigments absorb energy from sunlight to make food. Diatoms contain green chlorophyll – as do plants – but also a brown pigment called fucoxanthin, which serves to broaden the spectrum of light that can be used, making their photosynthesis significantly more efficient.

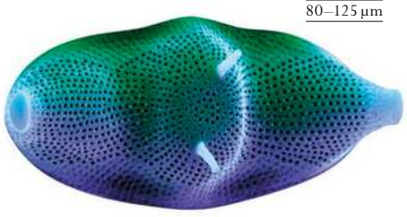
Brown algae occupy coastal habitats around the world. They also make use of fucoxanthin, and have evolved into complex multicellular seaweeds that superficially resemble a plant. Rather than true roots and leaves, their body consists of a holdfast for clasping to rock and a creeping thallus that lacks the internal veins of a true leaf. Nevertheless, some brown seaweeds, such as kelps, can grow to extraordinary lengths and make extensive underwater forests on some offshore coastlines.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
CLADE	HETEROKONTOPHYTA
FAMILIES	177
SPECIES	About 20,000

DEBATE

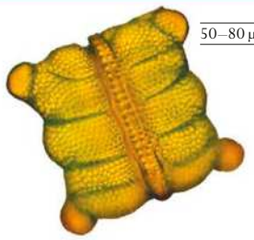
FROM ALGA TO MOULD

Water moulds grow and feed like mould, but unlike true moulds, which are fungi, have plant-like cell walls and heterokont flagella, while some also cause plant diseases. DNA analysis links them with diatoms and brown algae, so perhaps they evolved from algae that abandoned their chloroplasts and turned parasitic.



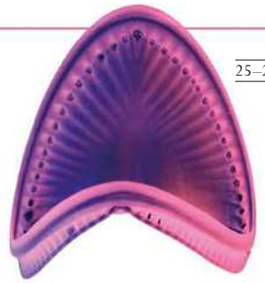
80–125 µm

EPIPHYTIC DIATOM
Biddulphia sp.
The cause of brown film on fish tanks, in the wild this species grows on seaweed and rocks.



50–80 µm

BARREL DIATOM
Biddulphia pulchella
This image clearly displays the different parts of a diatom: the two valves bound together by a narrow girdle.



25–200 µm

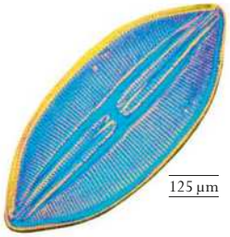
SADDLE DIATOM
Campylodiscus sp.
This genus of diatom shows a groove between the tubular lips, known as canals, around the edge of its valves.

0.3 mm/1/100 in

COLONIAL DIATOM
Isthmia nervosa
This species grows on other algae, specifically seaweeds, forming branching colonies.

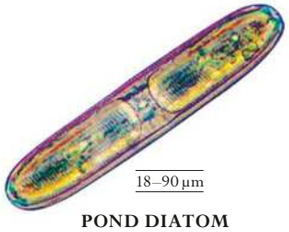
60–240 µm

***GYROSIGMA* SP.**
The name of this diatom refers to the sigmoidal curve of its cell, meaning that it follows a very slight S-shape.



125 µm

SLIMY DIATOM
Lyrella lyra
This species secretes a gluey slime from its central groove to help the cells to glide along their host's surface.

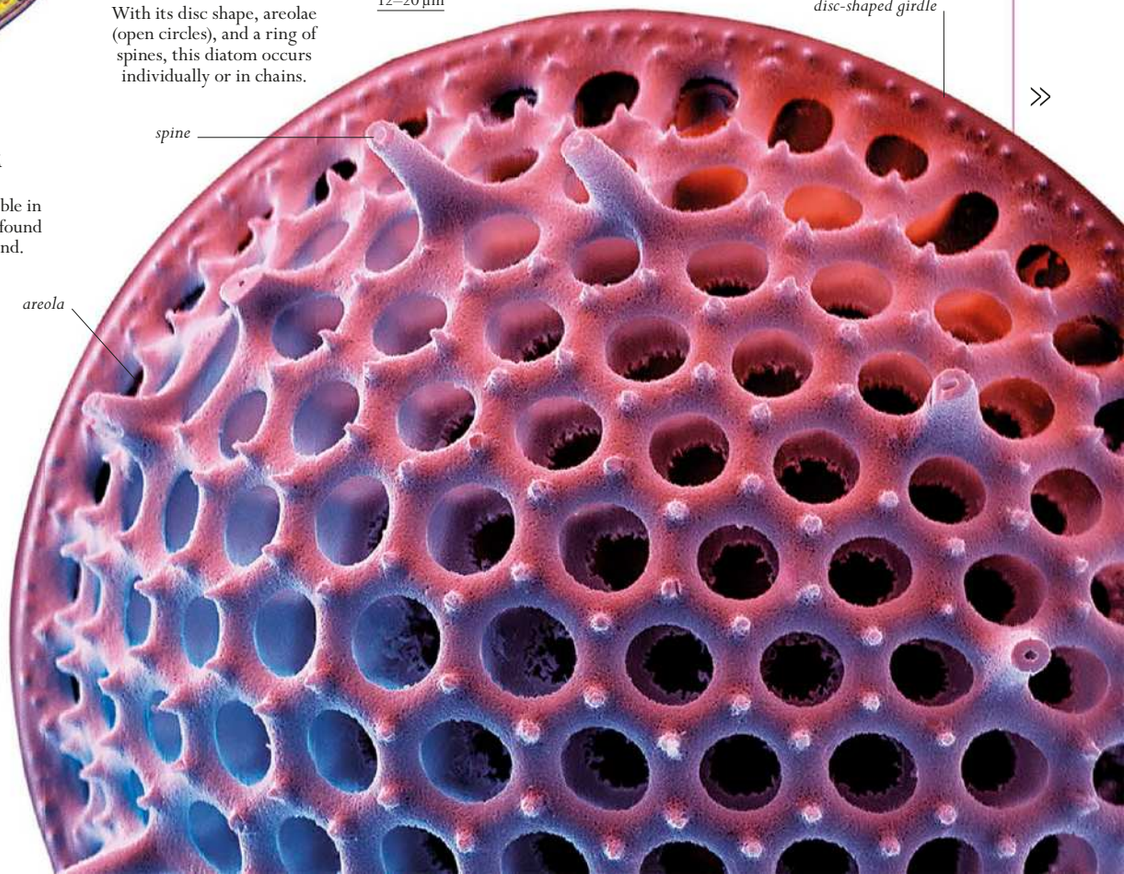


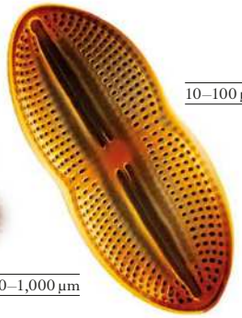
18–90 µm

POND DIATOM
Pinnularia sp.
Two chloroplasts are visible in this pen-shaped diatom, found in ponds and wet ground.

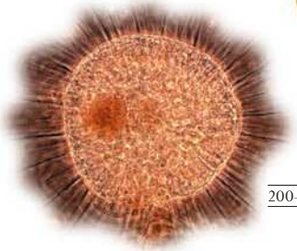
***STEPHANODISCUS* SP.**
With its disc shape, areolae (open circles), and a ring of spines, this diatom occurs individually or in chains.

12–20 µm





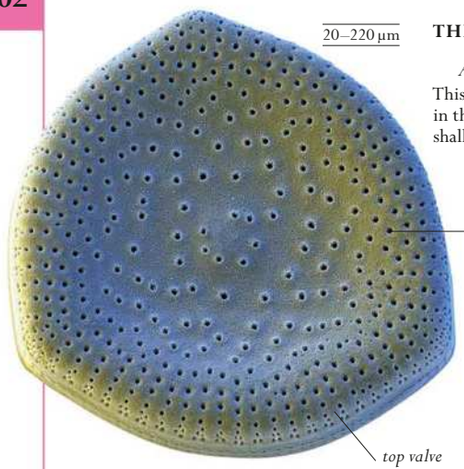
10–100 µm



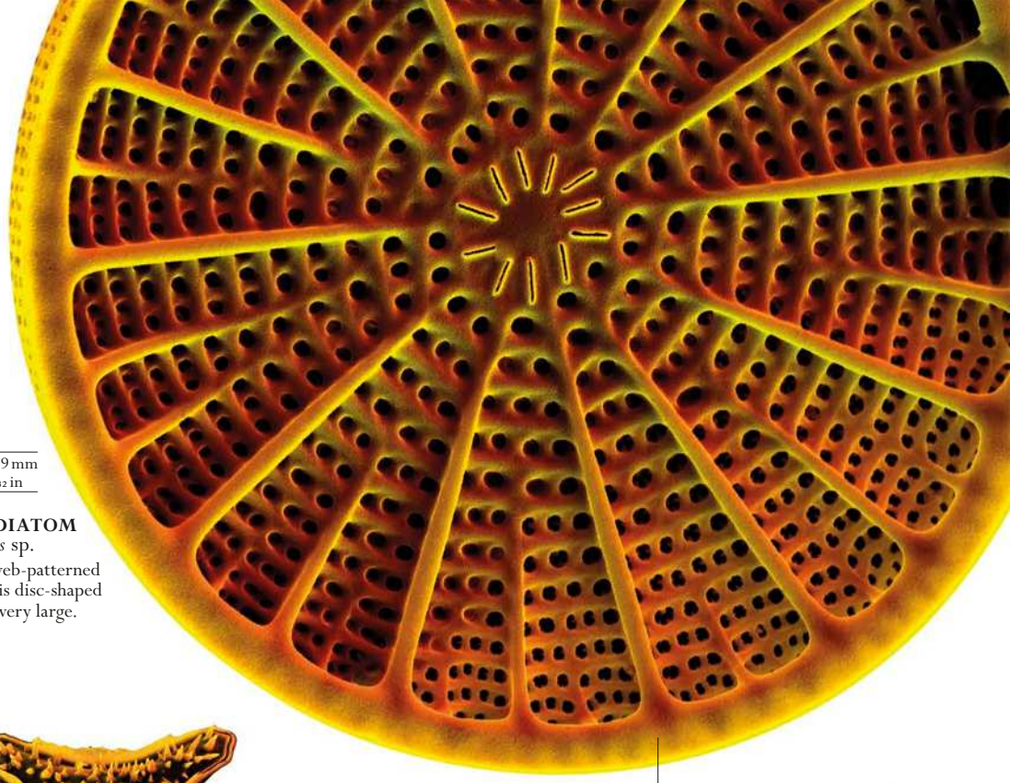
200–1,000 µm

URCHIN HELIOZOAN
Actinosphaerium sp.
This diatom resembles a sea urchin. It moves by shifting cell contents into its thin pseudopods.

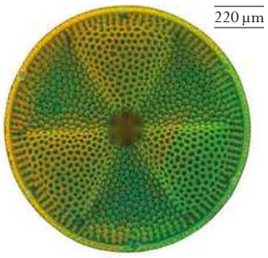
GROOVED DIATOM
Diploneis sp.
The valves of this species of diatom appear as two heavily pronounced lips, known as canals, either side of a slit-like groove known as a raphe.



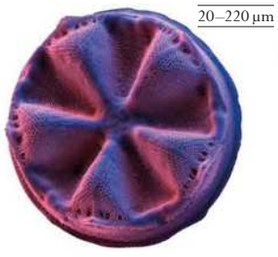
THREE-CORNERED DIATOM
Actinoptychus sp.
This diatom can be found in the neritic zone on the shallow continental shelf.



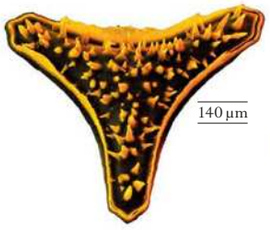
SPIDER'S-WEB DIATOM
Arachnoidiscus sp.
Strong radial ribs and web-patterned valves are features of this disc-shaped diatom. It can grow very large.



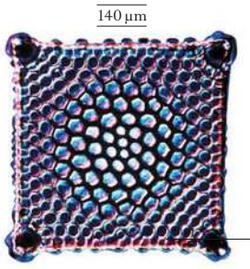
SUN-RAY DIATOM
Actinoptychus heliopelta
A distinctive pattern of alternating raised and depressed sectors on its top and bottom valves characterize this diatom species.



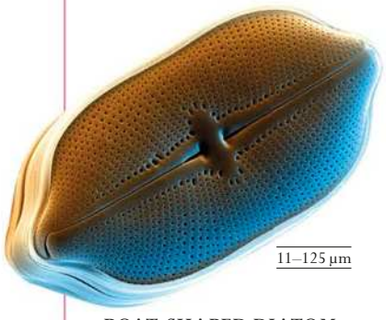
FIVE-ARMED DIATOM
Actinoptychus sp.
A five-arm appearance is produced by the alternating sectors on the valves of this species of the *Actinoptychus* genus.



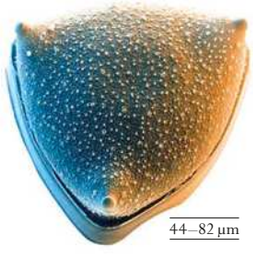
***TRICERATIUM* SP.**
More than 400 species of this genus of marine diatom are known. Diatoms of this genus are often, but not always, three sided.



TRICERATIUM FAVUS
The heavily silicified cell walls of this species can leave a trail of silica in the water as it moves. This can show how seawater penetrates into freshwater environments.



BOAT-SHAPED DIATOM
Navicula sp.
This species belongs to the largest genus of diatoms, which has thousands of species.



DAPPLED DIATOM
Stictodiscus sp.
Seen under a scanning electron microscope, this diatom shows pores dappled on its valve surface, above a surrounding girdle.

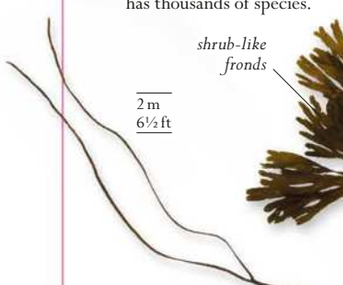
CUVIE
Laminaria hyperborea
This alga is commercially important in iodine production. It grows at depths of 8–30 m (26–100 ft), mainly in the northern hemisphere.

SEA OAK
Halidrys siliquosa
A large brown seaweed, common in rock pools in Europe, this species has a distinctive zigzag stem and air-filled pods known as air bladders.

WIREWEED
Sargassum muticum
Originally from Japan, this invasive brown seaweed has now spread to Europe. It can grow as much as 10 cm (4 in) in a day.

SUGAR KELP
Saccharina latifolia
Found on rocky shores and at depths of 8–30 m (26–100 ft) in northern seas, this brown seaweed is also often known as sugar wrack.

TOOTHED WRACK
Fucus serratus
This robust, shrubby, olive-brown seaweed grows on lower shores all round the North Atlantic.



THONGWEED
Himanthalia elongata
During its reproductive phase, this brown seaweed of the northern hemisphere produces long strap-like fronds, which are types of divided leaves.

RED ALGAE

Although some are microscopic organisms, the most familiar red algae are multicellular seaweeds, which are amongst the largest of the protoctists. They have evolved into an extraordinary diversity of forms, ranging from rock-hugging encrustations that look more like lichens to bristly or leafy clumps.

The great majority of the 6,500 or so species of red algae are marine, but there are a few freshwater species. Unlike brown and green algae, they do not produce flagellated sperm and rely instead on water currents to transport male sex cells to the female organs. The cells then merge, but subsequent development is highly variable between species.

RED FOR SURVIVAL

Like land plants, most algae use green chlorophyll to trap the energy of sunlight and manufacture food in the process of photosynthesis. However, the cells of red algae also contain a red pigment, called phycoerythrin, which masks the green colour of the chlorophyll and gives them their red colour – and their name. This pigment allows them to continue photosynthesizing even at depths in the water where only a little blue light can penetrate. This allows red algae to live much deeper in the oceans than brown or green seaweeds, and some have been reported growing as deep as 200 m (650 ft).

Some red algae become calcified, forming encrustations on rocks or hard, upright, antler-like forms. And, in spite of their name, their pigments can make red algae appear olive or grey.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
DIVISION	RHODOPHYTA
FAMILIES	92
SPECIES	About 6,500

DEBATE

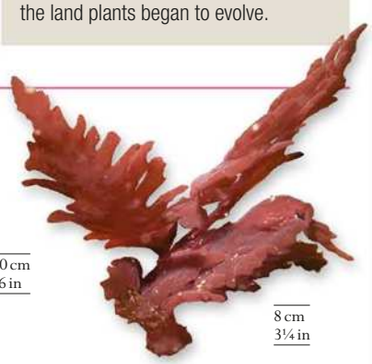
CLOSE RELATIVES?

Red algae were previously grouped with green algae, but it is now recognized that green algae are two separate and very diverse groups. Some species may be close to red algae, but others are closer to land plants. Red algae branched off the taxonomic tree before the land plants began to evolve.

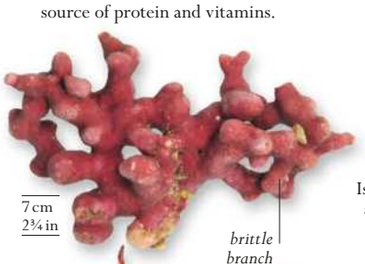
DULSE
Palmaria palmata
In N. Atlantic coastal communities, this edible seaweed is a traditional source of protein and vitamins.

CORAL WEED
Corallina officinalis
This red seaweed is common in rock pools worldwide, forming branching, feather-like fronds.

AGARDHIELLA SUBULATA
Originally from the western Atlantic, Caribbean, and Gulf of Mexico, this fleshy red alga has invaded some parts of Europe.



SCHMITZIA HISCOCKIANA
Found in areas swept almost bare by the tide, this red seaweed is fleshy and gelatinous, with flattened branches and finger-like projections.



MAERL
Phymatolithon calcareum
This species, an encrusting coralline alga of the British Isles, is commercially dredged and ground up as a calcium-rich soil additive.

BLACK CARRAGEEN
Furcellaria lumbricalis
This northern hemisphere seaweed has cylindrical, brown-black fronds that branch into masses of fleshy fingers.

EYELASH WEED
Calliblepharis ciliata
This northern hemisphere seaweed has flat fronds, fringed with numerous "branchlets".

GRACILARIA FOLIIFERA
Rising as slender dull purple stems, this red seaweed branches sparsely to give strap-like fronds. It grows abundantly in shallow lagoons worldwide.

GRACILARIA BURSA-PASTORIS
A long, thin red seaweed with forked or alternating branches, this species is found from southern England to the Pacific and the Caribbean.

MASTOCARPUS STELLATUS
This red seaweed has conspicuous papillae, which are reproductive bodies, on the fronds. It is found in the North Atlantic.

IRISH MOSS
Chondrus crispus
Also known as carrageen moss, this seaweed of the British Isles is important as a source of carrageen, which is a gelling agent.

» RED ALGAE

20 cm
8 in

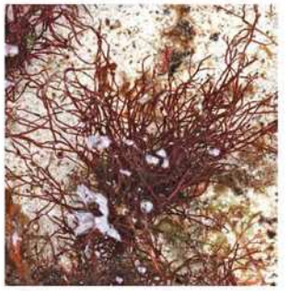
PTEROCLADIELLA CAPILLACEA

With feathery branches that taper towards the tip, this red seaweed, found in pools worldwide, often develops a Christmas tree-like appearance.

17 cm
6½ in

MELANAMANSIA FIMBRIFOLIA

Found in N. America and Australia, this seaweed grows on sediment-covered reefs at depths of up to 55 m (180 ft).



15 cm
6 in

BUSH WEED
Ahnfeltia sp.

A source of the gelatinous substance agar, used in petri dishes for cell culture, this northern-hemisphere seaweed forms dense tufts of fronds.

2.5 mm
1/10 in

SPOROLITHON PTYCHOIDES

This red algae forms a crust using calcareous deposits in its cell walls. It is found worldwide in rock pools and on current-swept rocky seabeds.

CHONDRIA DASYPHYLLA

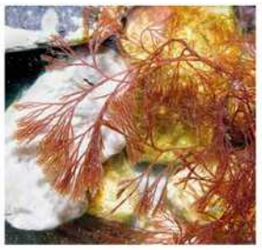
This species, found worldwide, has feathery fronds ending in club-like branchlets that sprout spore-bearing branchlets and urn-shaped fruit bodies.

10–21 cm
4–8½ in

7–22 cm
2¾–8¾ in

LAURENCIA OBTUSA

This tropical species is a source of halogenated terpenoids – chemical defences against grazing crabs and urchins – which also make useful anti-fouling agents.



30 cm
12 in

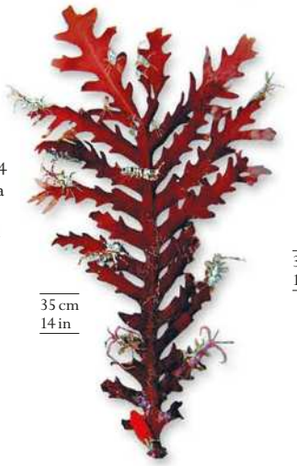
CERAMIUM VIRGATUM

This small red seaweed grows worldwide on rocks and other seaweeds. From a tiny holdfast it grows into filament-like fronds with forked tips.

20 cm
8 in

BROAD WEED
Lenormandiopsis nozawae

On both sides of this broad-bladed seaweed, found in temperate areas, are clusters of spore-bearing bodies, themselves home to tiny, parasitic algae.



LEATHER WEED
Ptilophora leliaertii

First described in 2004 after its discovery on a reef off the coast of South Africa, this red seaweed has feathery compound branches.

35 cm
14 in

30 cm
12 in

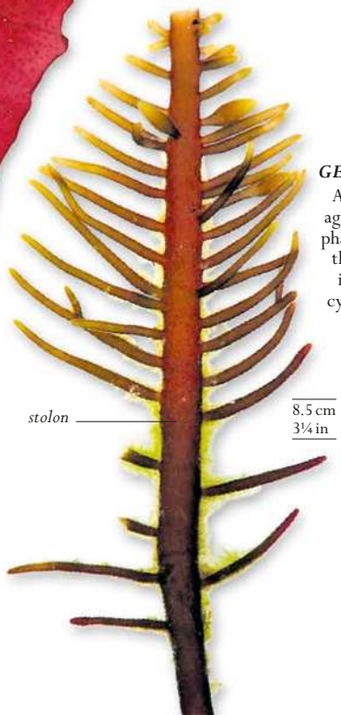
SEA BEECH
Delesseria sanguinea

Known for its characteristic beech-like leaves, this red seaweed grows in the understorey of kelp forests in Europe.

2–15 mm
1/10–3/5 in

GELIDIUM PUSILLUM

Growing worldwide from an extensive creeping base that incorporates shells and small snails, this turf-forming red seaweed has flattened, leaf-like fronds.



8.5 cm
3¼ in

GELIDIELLA ACEROSA

An important source of agar, used in the food and pharmaceutical industries, this red seaweed, found in India, has a slender, cylindrical shoot, known as a stolon.

2–10 cm
¾–4 in

POLYSIPHONIA LANOSA

Growing on other seaweeds in tufts like pom-poms in the northern hemisphere, this red alga has branching filaments made up of long tubular cells.

GREEN ALGAE

Green algae are a loose taxonomic aggregation of very diverse species. Some live in freshwater ponds and streams, some form green mats over damp, shady rocks or tree trunks, and others grow as leafy seaweeds, attached to rocks in shallow sea water.

Many green algae are microscopic and free-floating; others are multicellular with variably complex structures, including the blanketweeds that sometimes clog ponds. Some reproduce asexually by splitting, budding, or producing motile spores, but sexual reproduction is common in larger species. These typically produce sperm with two identical flagella, but also have spore-producing stages in their life cycle. The cells of green algae use the same chlorophyll pigments as land plants for photosynthesis, and they are sometimes included with them in an informal grouping called the Viridiplantae (green plants).

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
DIVISION	CHLOROPHYTA
FAMILIES	127
SPECIES	4,300

12–60 cm
4¾–23½ in

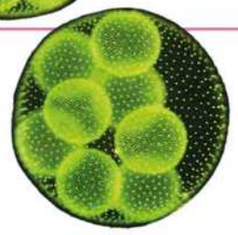
SEA LETTUCE
Ulva lactuca
A popular food worldwide, this green seaweed has broad, crumpled fronds, anchored to rock by a holdfast. It can also form floating communities.

5–40 cm
2–16 in

GREEN SEA FINGERS
Codium fragile
This tubular green alga occurs worldwide, in seashore rock pools and coastal waters to 2 m (6½ ft) deep.

2–5 m
6½–16 ft

SEA GRAPE
Caulerpa lentillifera
This edible seaweed produces many upright stalks from a long, creeping runner. In the Philippines, the succulent stalks are harvested and eaten raw in salads.



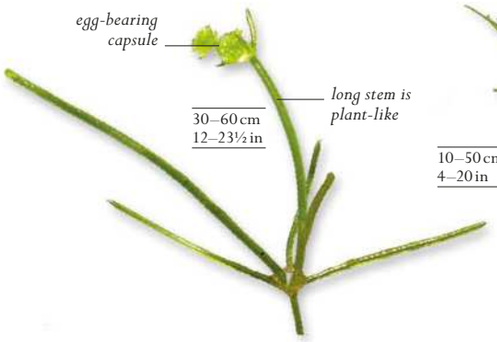
VOLVOX AUREUS
Just visible to the naked eye, spherical colonies of this freshwater alga consist of thousands of microscopic individuals. Thread-like flagellae spin the colony through the water.

STONEWORTS AND RELATIVES

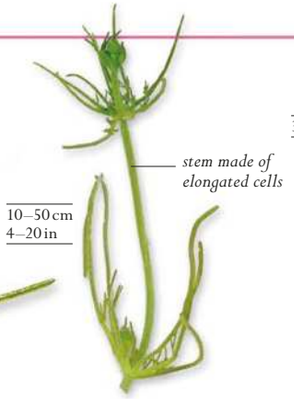
Although related to green algae, the stoneworts and their relatives have more complex structures and more advanced chemistry in their cells, suggesting that they are the ancestors of the true plants.

The Streptophyta (sometimes called Charophyta) includes desmids, which are classed as "conjugating green algae". These typically have a single cell, divided into two symmetrical semi-cells. However, the stoneworts and brittleworts are the best known group of streptophytes, and are often regarded as "honorary plants". They grow in the mud of shallow, freshwater or brackish habitats, rooted by cell filaments, called rhizoids, like the roots of simple plants. Their branched form and reproductive structures are also reminiscent of true plants. Indeed, some classification systems regard the Streptophyta as an "infra-kingdom" that also includes all of the land plants.

DOMAIN	EUKARYOTA
KINGDOM	PROTOCTISTA
DIVISION	STREPTOPHYTA
FAMILIES	16
SPECIES	2,700

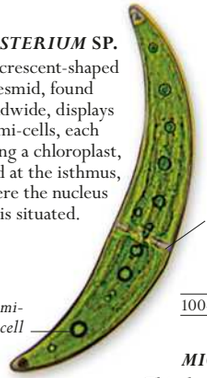


NITELLA TRANSLUCENS
This delicate "plant" with translucent green leaves grows in the clear water of ponds, streams, and fens around W. and S. Europe.

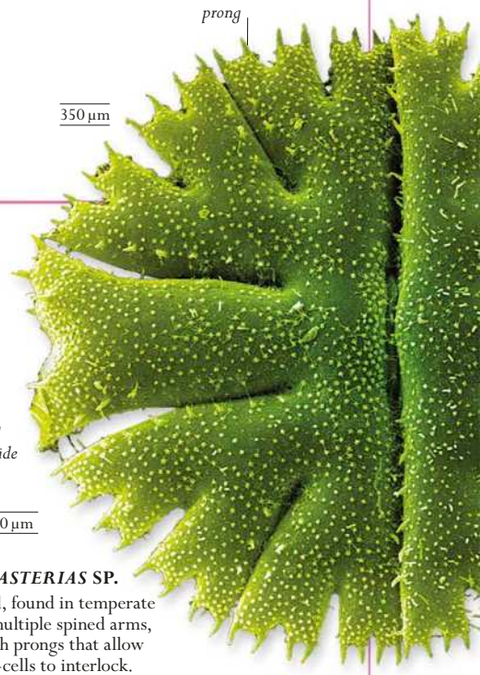


COMMON STONEWORT
Chara vulgaris
Also known as skunkweed, this streptophyte of the northern hemisphere emits an unpleasant smell.

***PENIUM* SP.**
This desmid, found in N. America, is symmetrically divided into cylindrical semi-cells with blunt, oval ends and girdle bands.



***CLOSTERIUM* SP.**
This crescent-shaped desmid, found worldwide, displays semi-cells, each housing a chloroplast, joined at the isthmus, where the nucleus is situated.



***MICRASTERIAS* SP.**
This desmid, found in temperate areas, has multiple spined arms, tipped with prongs that allow the semi-cells to interlock.

PLANTS

» 108

MOSSES

Widespread in damp, cool, and shaded places, mosses are non-flowering plants which have wiry stems and small, spirally arranged leaves. Many mosses grow on bare rocks and on trees.

» 110

LIVERWORTS

Related to mosses, liverworts also have no flowers, and spread by shedding spores instead of making seeds. They are typically small and ribbon-like, or straggling, with tiny leaves.

By harnessing the energy in sunlight, and using it to grow, green plants play a central role in life on Earth. They generate food for animals and other organisms, and often form their habitats as well. Some plants are small and simple, but they also include giant conifers, and a dazzling wealth of flowering species that have evolved a remarkable array of shapes and strategies for survival.

» 111

HORNWORTS • LYCOPHYTES

Hornworts are small plants, related to mosses, which produce spores from an elongated, horn-like structure. Lycophytes were previously thought to belong with the ferns, and include clubmosses.

» 112

FERNS AND RELATIVES

Ferns are the largest plants that reproduce with spores instead of seeds. Many are low-growing, but some form trees, which have trunks made of fibrous roots rather than wood.

» 116

CYCADS, GINKGOS, AND GNETOPHYTES

These plants do not have flowers, but they do form seeds. Before flowering plants evolved, cycads formed an important part of the world's vegetation.

» 118

CONIFERS

Although far fewer in species than flowering plants, conifers dominate the landscape in some parts of the world. All of them are trees or shrubs, and they typically form seeds in woody cones.

» 122

FLOWERING PLANTS

This is by far the largest group of living plants, making up the bulk of the world's vegetation. They all grow flowers – often inconspicuously – and spread by forming seeds.

MOSSES

Mosses are non-flowering plants that typically form mats or cushion-shaped clumps. Despite their small size, they are remarkably resilient plants. They are able to grow in a wide range of habitats, from woodland to deserts, and are found on every continent, including Antarctica.

DIVISION	BRYOPHYTA
CLASSES	8
ORDERS	30
FAMILIES	110
SPECIES	About 10,000

In the far north sphagnum mosses form raised bogs – here interspersed with grey patches of reindeer moss lichen.

Mosses have thin leaves that usually spiral around slender, wiry stems, and they reproduce by scattering spores. Like liverworts, they need moist conditions to grow. They can be extremely abundant in habitats that are always damp, and some species – particularly sphagnum mosses – form extensive soggy blankets, dominating the ground in cold parts of the world. Others, however, are able to remain dormant during droughts. They look grey and lifeless, but become green again within minutes if it rains.

Mosses have a two-stage life-cycle – a feature shared by all other plants. In mosses, the dominant stage is the gametophyte, which produces male and female cells. After the female cells are fertilized, they produce the spore-forming stages or sporophytes, which remain attached to the parent plant. Most moss sporophytes have a capsule on the end of a long stalk. Once ripe – a process that can take many months – the capsule splits open, releasing up to 50 million spores into the air.

Because moss spores are so small and light, they are carried great distances by the slightest breeze. This makes mosses very good at dispersing and enables them to colonize all kinds of micro-environments, from crevices in the bark of trees to damp walls and roofs.

RELATIVES AND LOOK-ALIKES

The division name Bryophyta is sometimes used to encompass the liverworts and hornworts (see pp.110–111), but these are now regarded as separate, but closely related, taxonomic divisions. Clubmosses are more complex than true mosses, and belong in the division Lycophyta (see p.111). Other moss look-alikes include reindeer moss – actually a form of lichen – and Spanish moss, a flowering plant in the bromeliad family, that grows festooned on trees.

∨ DEEP COVER
The cool, moist climate in New Zealand's Fjordland National Park enables a wide variety of mosses and liverworts to thrive.

BLACK ROCK MOSS
Andreaea rupestris
F: Andreaeaceae

Widespread on mountains, this dark-coloured moss grows on bare rock. Unlike most mosses, its capsules release their spores through four microscopic slits.

FIRE MOSS
Ceratodon purpureus
F: Ditrichaceae

Found worldwide, particularly on burned or disturbed ground, this low-growing moss is also common on roofs and walls. It produces a dense carpet of spore capsules in spring.

COMMON POCKET MOSS
Fissidens taxifolius
F: Fissidentaceae

This widespread moss has short, spreading stems bearing two ranks of pointed leaves. It grows in shaded ground and on rocks.

VELVET FEATHER-MOSS
Brachythecium velutinum
F: Brachytheciaceae

With its much-branched stems, this abundant moss forms creeping mats on dead wood and in poorly drained grass. It has a worldwide range.

WHITE FORK MOSS
Leucobryum glaucum
F: Dicranaceae

Growing in large, neatly rounded cushions, this woodland moss has a characteristic grey-green hue, turning almost white in dry weather.

MOUNTAIN FORK MOSS
Dicranum montanum
F: Dicranaceae

A moss that forms compact feathery mounds, this lowland species has narrow leaves that curl up when dry, sometimes breaking off to form new plants.

COMMON TAMARISK MOSS
Thuidium tamariscinum
F: Thuidiaceae

Its finely divided "fronds" make this woodland moss resemble a miniature fern. It grows on rotting wood and rocks in Europe and N. Asia.

PURPLE FORK MOSS
Grimmia pulvinata
F: Grimmiaceae

Growing on rocks, roofs, and walls, this widespread moss has leaves that end in long, silvery hairs. Its spore capsules grow on curved stalks.

SWAN'S NECK THYME MOSS
Mnium hornum
F: Mniaceae

Brilliant green in spring, this is a common woodland moss in Europe and N. America. Each spore capsule has a curved stalk resembling a swan's neck.

CYPRESS-LEAVED PLAIT MOSS
Hypnum cupressiforme
F: Hypnaceae

This highly variable mat-forming moss has crowded, overlapping leaves. Found worldwide, it is common on rocks and walls, and beneath trees.

OSTRICH-PLUME FEATHER MOSS
Ptilium crista-castrensis
F: Hypnaceae

Found mainly in northern forests, this moss has feather-shaped, symmetrically branched stems, often forming extensive patches below spruces and pines.

GREATER WATER-MOSS
Fontinalis antipyretica
F: Fontinalaceae

A submerged freshwater species, greater water-moss trails from rocks in slow-flowing rivers and streams. It has three rows of keeled, dark green leaves.

CAPE THREAD-MOSS
Orthodontium lineare
F: Bryaceae

This moss from the southern hemisphere was introduced to Europe in the early 20th century and has become an invasive species.

BLUNT-LEAVED BOG MOSS
Sphagnum palustre
F: Sphagnaceae

Like its relatives, this peat-forming moss grows on wet ground, and holds large amounts of water. Each stem ends in a flat-topped rosette of small branches.

COMMON HAIR-CAP MOSS
Polytrichum commune
F: Polytrichaceae

This tall, tussock-forming moss is common in wet moorland throughout the northern hemisphere. Its stems are stiff and unbranched, with narrow, pointed leaves.

BONFIRE MOSS
Funaria hygrometrica
F: Funariaceae

One of the world's most widespread mosses, this mat-forming species is particularly common on disturbed ground and sites of recent fires. Its ripe spore capsules have orange stalks.

LIVERWORTS

Found mainly in damp, shaded habitats, liverworts are thought to be the simplest of all the existing groups of land plants. They come in two distinct forms: some are flat and ribbon-like; others are more like mosses, with slender stems flanked by tiny leaves.

DIVISION	MARCHANTIOPHYTA
CLASSES	3
ORDERS	16
FAMILIES	88
SPECIES	About 7,500

DEBATE

PLANTS APART

Liverworts have unique features that distinguish them from mosses and hornworts, although they were once all grouped together as bryophytes. They are the only land plants without stomata, or breathing pores, in their sporophyte (spore-producing) stage. Also, their hair-like "roots" are single-celled. They are therefore classed in their own division Marchantiophyta.

Ribbon-like liverworts look unlike any other plants. Instead of stems and leaves, they have a flat body, or thallus, that repeatedly forks as it grows. Many species have a glistening upper surface with deeply divided lobes. Medieval herbalists noted this liver-like shape, giving the plants their common name. Leafy liverworts look quite different, with trailing or spreading stems. They usually have two ranks of leaves, with a third row of smaller leaves on their underside. Some kinds form loose mats in damp grass, and others grow on rocks. They are much more numerous than ribbon-like liverworts, especially in the tropics, where many species live epiphytically on rainforest trees.

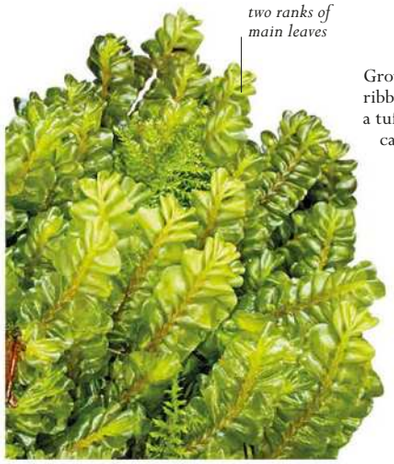
SPREADING THEIR KIND

Unlike most flowering plants, liverworts have no preset limits to their growth. They can form patches up to several metres across, which gradually fragment as they grow, forming multiple plants. In addition, some species have cell clusters, called gemmae, in depressions on their upper surface. Raindrops scatter these gemmae, which grow into new plants.

Liverworts also reproduce by scattering spores, microscopic cells that form new plants. Spore formation requires damp conditions, because a liverwort's female cells must first be fertilized by swimming male sperm. Sperm cells often reach egg cells with the help of raindrops, which splash them from one plant to another. Many liverworts produce their sperm or egg cells in structures that look like tiny parasols. After fertilization, the developed spores are scattered into the air.

GREATER WHIPWORT
Bazzania trilobata
F: Lepidoziaceae
A native of damp woodland, this mound-forming liverwort has main leaves that overlap and curve downwards, giving its stems a caterpillar-like shape.

CRESCENT-CUP LIVERWORT
Lunularia cruciata
F: Lunulariaceae
Common in gardens and greenhouses, this ribbon-shaped liverwort is bright green, with distinctive reproductive structures, gemma cups, that look like tiny fingernails.



GREATER FEATHERWORT
Plagiochila asplenioides
F: Plagiochilaceae
A delicate liverwort with translucent leaves, this species forms spreading, moss-like tufts. It grows on shaded rocks and soil, particularly on chalk and limestone.

OVERLEAF PELLIA
Pellia epiphylla
F: Pelliaceae
Growing on wet peat and rocks, this ribbon-shaped liverwort often forms a tufted mat. It produces black spore capsules on slender white stalks.

EVEN SCALEWORT
Radula complanata
F: Radulaceae
Ranging in colour from light green to brown, this scaly-leaved liverwort creeps over flat, unshaded surfaces as varied as tree trunks and coastal rocks.

MALE REPRODUCTIVE STRUCTURES

COMMON LIVERWORT
Marchantia polymorpha
F: Marchantiaceae
In spring and summer this ribbon-shaped liverwort produces conspicuous spore-forming structures that look like tiny parasols. It is widespread in damp habitats and gardens.

HORNWORTS

Hornworts are the third division in the informal grouping called bryophytes. They are small, easily overlooked, leafy plants found in damp places worldwide.

Like mosses and liverworts, hornworts have two generations in their life cycle: a vegetative gametophyte and a spore-bearing sporophyte. The gametophytes form flattened, leafy lobes, rather like some liverworts, up to 5 cm (2 in) in diameter. In their sporophytes, the spores are released from a characteristic, elongated horn-like structure, which gives them their name. Some species grow as tiny weeds on the soil of gardens or cultivated fields. Other, rather larger, tropical and subtropical species grow mainly on the bark of trees. These hornworts do not produce flowers, unlike the small order of flowering water plants that, confusingly, are also called hornworts (see p.124).

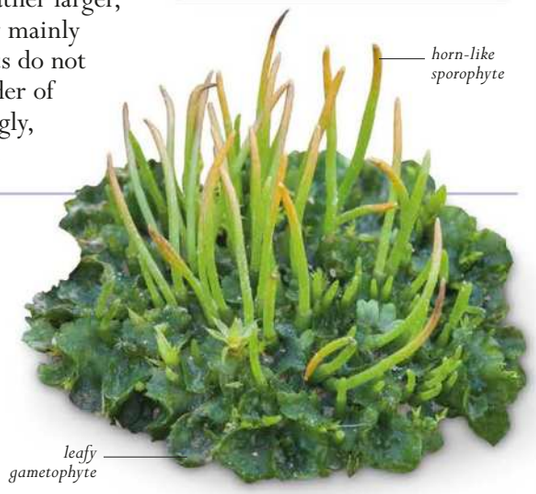
DIVISION	ANTHOCEROTOPHYTA
CLASSES	2
ORDERS	5
FAMILIES	5
SPECIES	About 220

DENDROCEROS
Dendroceros sp.
F: Dendrocerotaceae

The ribbon-like lobes of dendroceros gametophytes spread across damp rocks or tree bark in tropical and subtropical forests. The horn-like sporophyte grows from this, up to 5 cm (2 in) tall.

FIELD HORNWORT
Anthoceros agrestis
F: Anthocerotaceae

Damp stubble fields, trampled ground, and the sides of ditches are home to this inconspicuous hornwort with distinctive, frilly leaf lobes. It is found across temperate Europe and N. America.



CAROLINA HORNWORT
Phaeoceros carolinianus
F: Notothyladaceae

Growing in similar places to field hornwort, this species has separate male and female gametophytes. Raindrops carry sex cells from leaf pits on males to fertilize females, allowing sporophytes to develop.

LYCOPHYTES

Although their taxonomy is still under review, lycophytes include clubmosses and quillworts, plants which are closely related to, but distinct from, ferns.

Lycophytes are the first plants in this book that have a vascular system, a network of conducting tissues that transport water, minerals, and nutrients around their roots, stems, and leaves. This allows lycophytes to grow taller and survive in drier habitats than bryophytes. Fossil lycophytes date back 425 million years. They were dominant plants during the Carboniferous era. Some then were tree-sized, unlike their smaller modern relatives. Lycophytes spread by spores, produced in sporangia (spore cases) at the base of simple leaves.

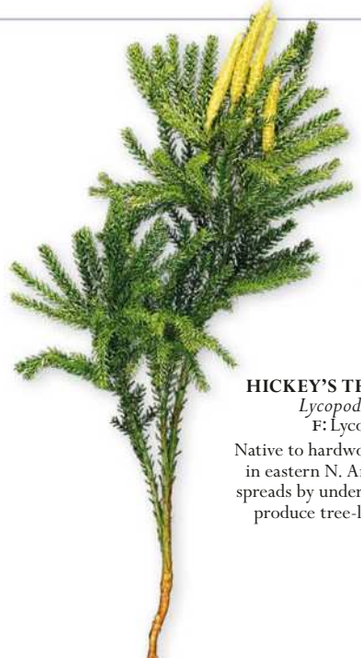
DIVISION	LYCOPHYTA
CLASSES	1
ORDERS	3
FAMILIES	3
SPECIES	About 170

IBERIAN QUILLWORT
Isoetes longissimi
F: Isoetaceae

Quillworts grow in slow-moving streams and clear ponds. They have densely tufted, hollow leaves, with spore cases hidden in their swollen bases.

INTERRUPTED CLUBMOSS
Lycopodium annotinum
F: Lycopodiaceae

This clubmoss of northern moors and mountains produces spores from cone-like clusters at the tip of its upright stems.



HICKEY'S TREE-CLUBMOSS
Lycopodium hickeyi
F: Lycopodiaceae

Native to hardwood forests and scrub in eastern N. America, this species spreads by underground stems which produce tree-like, fertile fronds.

STAGHORN CLUBMOSS
Lycopodiella cernua
F: Lycopodiaceae

Lycopodiella species are generally more delicate than other clubmosses. Looking like a miniature pine tree, staghorn clubmoss grows in bogs throughout the tropics.

FERNS AND RELATIVES

Most ferns can be recognized by their graceful fronds, which unroll as they grow. Together with horsetails and whisk ferns, they make up a diverse and ancient group of non-flowering plants that reproduce by means of spores. Ferns grow in a wide variety of habitats, although the majority thrive where there is moisture and shade.

DIVISION	POLYPODIOPHYTA
CLASSES	1
ORDERS	11
FAMILIES	40
SPECIES	About 12,000

DEBATE

LIVING FOSSILS

Horsetails have been around for over 300 million years. One of the largest extinct genera, called *Calamites*, grew up to 20 m (65 ft) tall, and had massive ridged stems over 60 cm (23½ in) across. The 20 or so species of horsetails that survive today are much smaller plants, growing in water, woodland, and disturbed ground. They look very different from ferns, producing their spores in cone-like structures at the tips of some of their stems, but most botanists now agree that they should be classified as an order within the ferns.

Some ferns are small and easily overlooked, but the group also includes large, tree-like species that can be over 15 m (50 ft) high. Many are compact plants, with a single cluster of fronds, but others have creeping stems that sprout fronds as they spread. Bracken – one of the most widespread creeping species – is particularly vigorous. Over many years, it can produce clumps, or clones, over 800 m (½ mile) across. Ferns also include species that live in fresh water and a wide variety of epiphytic species, which live on other plants.

Fern fronds are often finely divided, and usually develop from tightly coiled buds, known as croziers or fiddleheads. Spores are formed on the underside of the fronds, in structures that look like raised dots or lines. In many fern species, all the fronds produce spores, but some have two kinds of fronds: fertile fronds form spores, while sterile fronds are primarily adapted to collecting sunlight so the fern can grow. When a fern spore germinates, it develops into an intermediate stage known as a gametophyte. Tiny, flat, and paper-thin, this eventually produces a new sporophyte – the spore-forming plant we recognize as a fern.

FERN RELATIVES

Fern taxonomy is in a state of flux, but all the scientific evidence suggests that ferns are more closely related to seed plants (gymnosperms and angiosperms) than to the lycophytes with which they were once grouped.

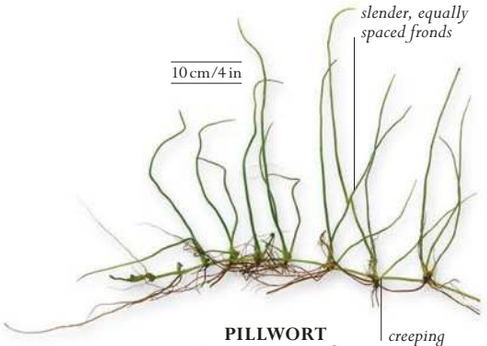
The fern division also includes horsetails, which are upright plants with hollow, cylindrical stems, surrounded by whorls of slender branches. Silica granules give them a rough texture, and they were once used for scouring pots and pans. Adder's tongues and whisk ferns are distinctive groups, with twig-shaped stems or a single, divided frond, that are also classed within the ferns.

CHARACTERISTIC COIL
The delicate tips of young fern fronds are protected inside tight coils. These unwind as they stretch upwards towards the light.

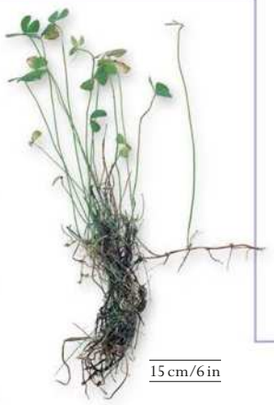
HORSETAILS

COMMON HORSETAIL
Equisetum arvense
F: Equisetaceae
Widespread in the northern hemisphere, this horsetail can be a troublesome weed. Its black underground rhizomes sprout hollow shoots, bearing symmetrical rings of bright green branches.

TRUE FERNS



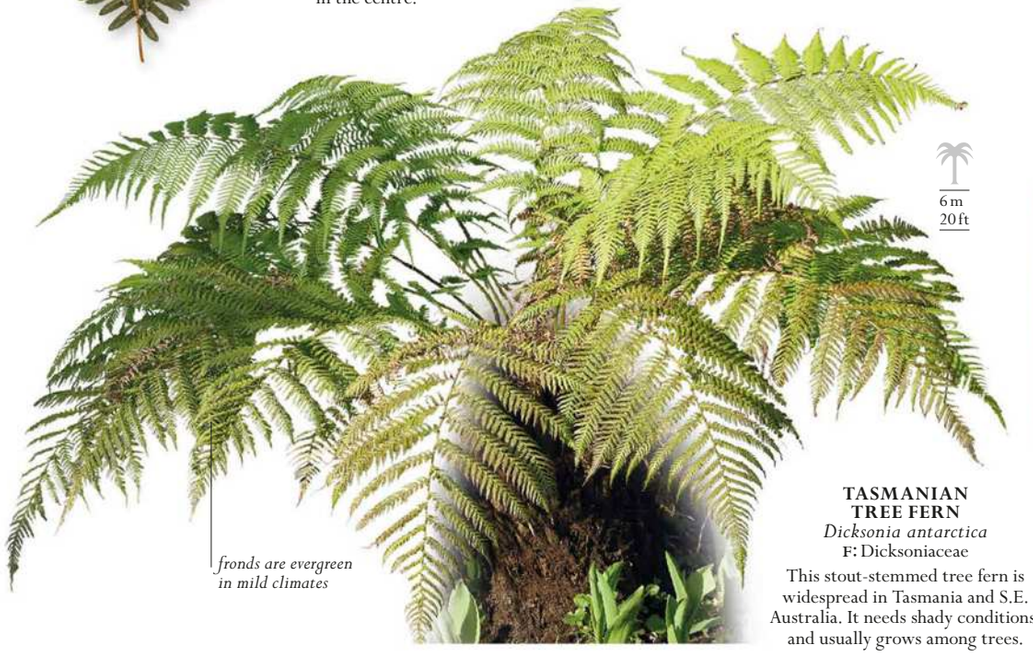
PILLWORT
Pilularia globulifera
F: Marsileaceae
This marshland fern from W. Europe forms clumps resembling tufts of grass. Its spores develop at ground level, in green capsules shaped like pills.



WATER CLOVER
Marsilea quadrifolia
F: Marsileaceae
With its four-lobed fronds, this clump-forming aquatic fern looks deceptively like a flowering plant. It is widely distributed across the northern hemisphere.

ROYAL FERN
Osmunda regalis
F: Osmundaceae
Often cultivated, this stately fern from the northern hemisphere has a rosette of spreading fronds with several narrower, spore-bearing fronds in the centre.

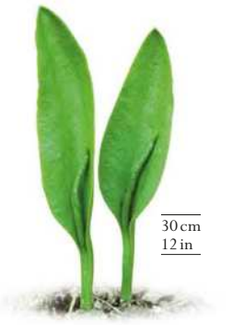
FLOATING FERN
Salvinia natans
F: Salviniaceae
Often forming a dense carpet, this water fern has small, oval leaves covered with water-repellent hairs. It is common throughout the tropics.



TASMANIAN TREE FERN
Dicksonia antarctica
F: Dicksoniaceae
This stout-stemmed tree fern is widespread in Tasmania and S.E. Australia. It needs shady conditions, and usually grows among trees.

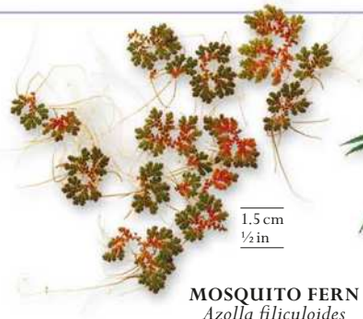
WHISK FERNS, MOONWORTS, AND ADDER'S TONGUES

WHISK FERN
Psilotum nudum
F: Psilotaceae
A primitive relative of true ferns, this largely tropical plant has leafless, brush-like stems, bearing berry-like capsules that produce its spores.



ADDER'S TONGUE FERN
Ophioglossum vulgatum
F: Ophioglossaceae
This unusual fern has a single, oval frond, clasping a slender, spore-producing stalk. It grows in grassy places throughout the northern hemisphere.

COMMON MOONWORT
Botrychium lunaria
F: Ophioglossaceae
Found worldwide in temperate regions, moonwort has a single vegetative frond and a fertile frond topped by a cluster of spore capsules.



MOSQUITO FERN
Azolla filiculoides
F: Salviniaceae
A floating plant with mat-forming fronds, mosquito fern spreads rapidly across lakes and ponds. It is widespread in warm parts of the world.

UMBRELLA FERN
Sticherus cunninghamii
F: Gleicheniaceae
This distinctive fern from New Zealand has a pencil-thin stem topped by a horizontal crown of narrow, radiating fronds. It spreads by creeping rhizomes.

SILVER TREE FERN
Alsophila dealbata
F: Cyatheaceae
This tree fern gets its name from its fronds, which have a silvery underside. Native to New Zealand, it grows in open forest and scrub.

BLACK TREE FERN
Sphaeropteris medullaris
F: Cyatheaceae
From New Zealand, this tall and slender tree fern has a sooty-black trunk and dark leaf stalks, contrasting with its bright green fronds.

SOFT TREE FERN
Alsophila smithii
F: Cyatheaceae
Native to New Zealand and sub-Antarctic islands, this is the most southerly tree fern. It often has a collar of dead fronds hanging beneath its crown.

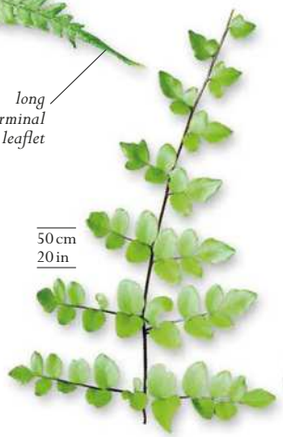
»

SILVER BRAKE
Pteris argyraea
F: Pteridaceae

This shade-loving fern is named for its distinctive fronds, which have a silvery white central stripe. Originally from S.E. Asia, it is widely grown as a houseplant.

PAINTED BRAKE
Pteris tricolor
F: Pteridaceae

From Malaysia, painted brake has an unusual range of colours: its metallic-looking, copper-coloured young fronds turn green as they mature.



CLIFF BRAKE
Pellaea viridis
F: Pteridaceae

Native to South Africa, this drought-resistant fern has shining green fronds with wiry, black stems. It grows in open woodland on mountains.

BLACK MAIDENHAIR FERN
Adiantum capillus-veneris
F: Pteridaceae

Found in crevices on limestone, this widespread fern has bright green, translucent leaflets that contrast with its slender black stems.

SILVER LIP FERN
Cheilanthes argentea
F: Pteridaceae

From E. Asia, this small, evergreen fern has wedge-shaped fronds with black veins and distinctive silvery markings on their underside.

NORTHERN BEECH FERN
Phegopteris connectilis
F: Thelypteridaceae

Found as far north as Greenland, this compact fern grows in a variety of habitats from woodland to rocky tundra.

MOUNTAIN FERN
Oreopteris limbosperma
F: Thelypteridaceae

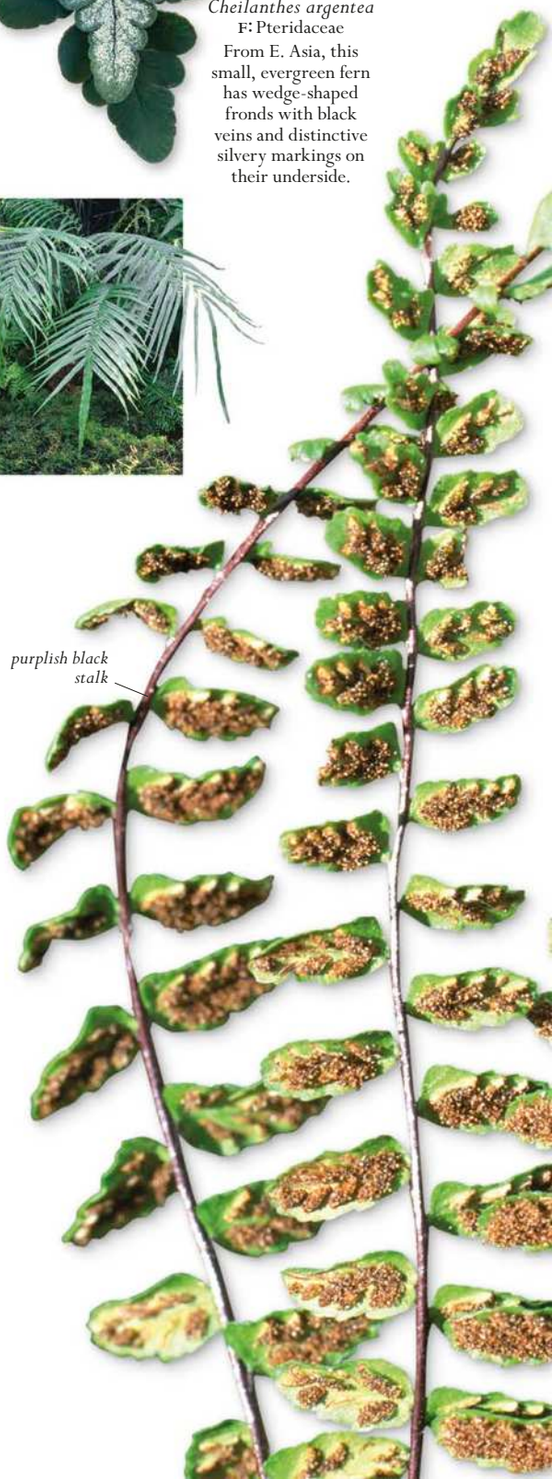
Found in damp habitats on acid soil, this clump-forming European fern gives off a characteristic lemony smell if its fronds are bruised.

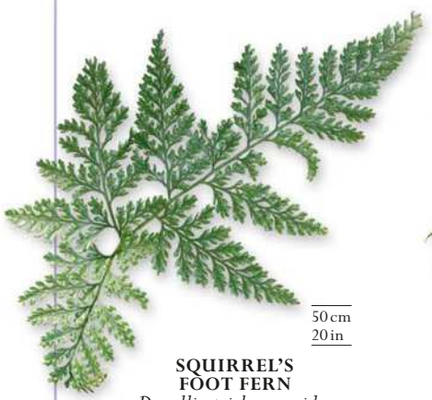
LADDER BRAKE
Pteris vittata
F: Pteridaceae

Widespread in warm regions, this fern has upright or arching fronds with narrow, linear leaflets. It usually grows on limestone and in alkaline soils.

BRACKEN
Pteridium aquilinum
F: Dennstaedtiaceae

Found on every continent except Antarctica, bracken spreads vigorously by growing underground rhizomes. It often dies back in winter, sprouting new fronds in spring.





SQUIRREL'S FOOT FERN
Davallia trichomanoides
F: Davalliaceae

This epiphytic fern from Malaysia creeps over trees and other plants. Its rhizomes have fur-like scales and tips that resemble a squirrel's foot.

EUROPEAN CHAIN FERN
Woodwardia radicans
F: Blechnaceae

Native to S.W. Europe and Algeria, this is a luxuriant fern of damp, shaded habitats. Its arching fronds sometimes produce bulbils (small bulbs) at their tips.

HARD FERN
Blechnum spicant
F: Blechnaceae

This evergreen fern has spreading sterile fronds, and upright fertile fronds with leaflets like narrow ribs. It is native to the temperate northern hemisphere.

1.2 m
4 ft

SOFT SHIELD FERN
Polystichum setiferum
F: Dryopteridaceae

Native to damp European woodlands, soft shield fern has feather-shaped fronds, with leaflets turned at an angle, instead of lying flat.

40 cm
16 in

OAK FERN
Gymnocarpium dryopteris
F: Cystopteridaceae

Delicate bright green fronds, sprouting separately, distinguish this northern fern. It grows in shaded screes as well as in woodland.

1.5 m
5 ft

fronds form cone-shaped crown

OSTRICH FERN
Matteuccia struthiopteris
F: Onocleaceae

Native to the northern hemisphere, this tall waterside fern has a symmetrical crown of sterile fronds in summer, followed by brown fertile fronds in the winter.

30 cm
12 in

1.2 m
4 ft

MALE FERN
Dryopteris filix-mas
F: Dryopteridaceae

One of the commonest woodland ferns in Europe, this species has a crown of concentric fronds shaped like the tail of a shuttlecock.

spore capsules on underside of fronds

20 cm
8 in

MAIDENHAIR SPLEENWORT
Asplenium trichomanes
F: Aspleniaceae

Occurring from the tropics to sub-Arctic regions, this small clump-forming fern grows in rocky places. Its fronds have paired elliptical leaflets.

40 cm
16 in

toothed, pale green leaflets

BRITTLE BLADDER-FERN
Cystopteris fragilis
F: Cystopteridaceae

Named for its swollen spore capsules borne on the underside of its fronds, this fern grows in temperate regions worldwide.

60 cm
23½ in

winged midrib

SENSITIVE FERN
Onoclea sensibilis
F: Onocleaceae

The fronds of this wetland fern from N. America and E. Asia seem very sensitive to cold, dying soon after the first frosts.

60 cm
23½ in

HART'S TONGUE FERN
Asplenium scolopendrium
F: Aspleniaceae

With its glossy, strap-shaped fronds, this fern is often cultivated as an ornamental plant. It grows wild in Europe, W. Asia, and N. America.

15 cm
6 in

WALL RUE
Asplenium ruta-muraria
F: Aspleniaceae

Widespread across the northern hemisphere, this small tuft-forming fern grows on limestone rocks and on walls containing lime-rich mortar.

90 cm
35 in

COMMON STAGHORN FERN
Platycerium bifurcatum
F: Polypodiaceae

Found in Indonesia and Australasia, this impressive epiphyte grows on tree-trunks. It has kidney-shaped sterile fronds and spreading fertile fronds shaped like antlers.

COMMON POLYPODY
Polypodium vulgare
F: Polypodiaceae

Instead of forming clumps, this fern sprouts separate fronds along its creeping rhizome. It is common on rocks, trees, and leaf litter in northern temperate regions.

CYCADS, GINKGOS, AND GNETOPHYTES

Found mainly in warm parts of the world, the cycads, ginkgos, and gnetophytes are three ancient divisions of non-flowering plants with strikingly varied shapes. They range from climbers and low-growing shrubs to plants that are easily mistaken for palms.

DIVISION	CYCADOPHYTA
CLASS	1
ORDER	1
FAMILIES	2
SPECIES	330

DIVISION	GINKGOPHYTA
CLASS	1
ORDER	1
FAMILY	1
SPECIES	1

DIVISION	GNETOPHYTA
CLASS	1
ORDERS	1
FAMILIES	3
SPECIES	70

BUILT TO LAST
Like palms, cycads usually have a single crown of compound leaves, surrounding a central growing point, or apical meristem. Their tough leaves are able to withstand strong sunshine and drying winds.

These three groups are traditionally classed, along with conifers, as gymnosperms – a word that means "naked seed". Unlike flowering plants, gymnosperms form their seeds on exposed surfaces, which are typically specialized scales. Flowering plants produce their seeds in closed chambers, or ovaries.

Scientists have not yet resolved the exact relationship between cycads, ginkgos, and gnetophytes. Nor can they say where they stand in relation to conifers and flowering plants. At the cellular level, some features of gnetophytes suggest they are more closely related to conifers than to cycads and ginkgos, but they also have features in common with flowering plants.

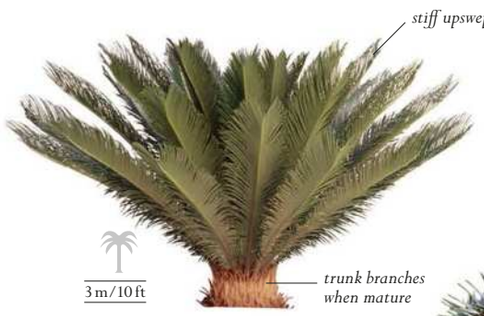
Apart from the nature of their seeds, the three groups have little in common, and hardly ever grow in the same place. Cycads grow mainly in the tropics and subtropics, while the single surviving species of ginkgo comes from China. Gnetophytes are more diverse, including trees and climbers from the tropics, densely branched shrubs from dry habitats, and the bizarre *Welwitschia*, which grows only in the Namib Desert of southwest Africa.

VARYING FORTUNES

Cycads have a long history, dating back nearly 300 million years. Once an important part of the world's vegetation, they have gradually lost ground in the face of competition from flowering plants. Today, nearly a quarter of cycad species are endangered, under threat from illegal plant collection and habitat change.

Gnetophytes face fewer problems, and the ginkgo has seen a dramatic improvement in its status. For centuries it was preserved by Buddhist monks, who grew it in temple gardens long after it had vanished in the wild. Introduced to Europe in the 1700s, it proved easy to grow and highly tolerant of polluted air. It is now planted worldwide in parks and city streets.

CYCADS



JAPANESE SAGO PALM
Cycas revoluta
F: Cycadaceae
Unrelated to true sago, this palm-like cycad from S. Japan has a thick stem and glossy leaves. It is widely cultivated as an ornamental plant.

EASTERN CAPE BLUE CYCAD
Encephalartos horridus
F: Zamiaceae
Unlike most cycads, this low-growing semi-desert species from South Africa has grey-blue leaves, composed of stiff leaflets armed with sharp spines.

1.4 m/4½ ft

6 m/20 ft

PRICKLY CYCAD
Encephalartos altensteinii
F: Zamiaceae
Found near South Africa's eastern coast, this tall, subtropical cycad is named for the toothed edges of its leaves. Its yellow cones produce bright red seeds.

7 m
23 ft

MEXICAN FERN PALM
Dioon edule
F: Zamiaceae
A cycad rather than a true palm, this slow-growing plant from E. Mexico has oval seed cones up to 30 cm (12 in) long.

1.8 m
6 ft

2 m/6½ ft

MEXICAN HORNCONE
Ceratozamia mexicana
F: Zamiaceae
This robust cycad from E. Mexico has a large crown of spreading leaves and grey-green cones with distinctive horns on their scales.

1.2 m
4 ft

COONTIE
Zamia pumila
F: Zamiaceae
Once used as a source of starch, this dwarf cycad from the Caribbean has a short, half-buried stem and upright reddish-brown cones.

MACROZAMIA MOOREI
F: Zamiaceae
One of Australia's tallest cycads, this palm-like plant has giant seed cones up to 90 cm (36 in) long. It grows in dry woodland.

3 m/10 ft

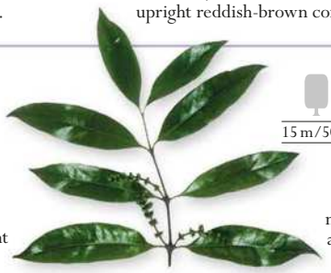
BURRAWONG
Macrozamia communis
F: Zamiaceae
Native to Australia's southeast coast, this cycad has large cones with red, fleshy seeds. It often grows in dense stands.

GNETOPHYTES

2 m/6½ ft

LONGLEAF JOINT-FIR
Ephedra trifurca
F: Ephedraceae
Also known as Mormon tea, this mound-forming plant has stems ringed by scale-like leaves. It grows in deserts in Mexico and the southern USA.

CHINESE EPHEDRA
Ephedra sinica
F: Ephedraceae
This straggling plant from E. Asia contains powerful alkaloids and has a long history of use as a medicinal herb.



15 m/50 ft

MELINJO
Gnetum gnemon
F: Gnetaceae
A non-flowering tree from S.E. Asia and the Pacific, melinjo has evergreen leaves and nut-like seeds. Both are used in cooking.

GINKGO

30 m/100 ft

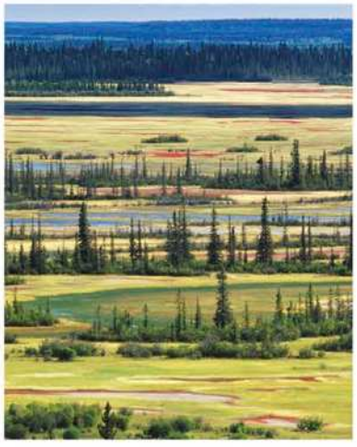
MAIDENHAIR TREE
Ginkgo biloba
F: Ginkgoaceae
This distinctive tree is easily recognized by its fan-shaped leaves, which turn bright yellow in autumn. Originally restricted to S. China, it is now cultivated worldwide.

WELWITSCHIA
Welwitschia mirabilis
F: Welwitschiaceae
Endemic to the Namib Desert, this extremely long-lived plant has a single pair of strap-shaped leaves. Over the centuries they crack and split, creating a tangled mound of foliage.

CONIFERS

Conifers evolved over 300 million years ago, long before the world's first broadleaved trees. With their tough waxy leaves, conifers thrive in harsh climates. They are less diverse than broadleaved trees, but they dominate forests on cold mountains, and in the far north.

DIVISION	PINOPHYTA
CLASS	1
ORDER	2
FAMILIES	6
SPECIES	About 600



Between areas of open tundra, conifers grow far to the north of the Arctic Circle, forming the largest forest on Earth.

Although relatively few in species, conifers include the world's tallest trees, as well as the heaviest, the longest-lived, and some of the most widespread. Conifers are traditionally placed in a group known as gymnosperms, along with cycads, ginkgos, and gnetophytes. Unlike broadleaved trees, they do not have flowers and produce pollen and seeds in cones.

LEAVES AND CONES

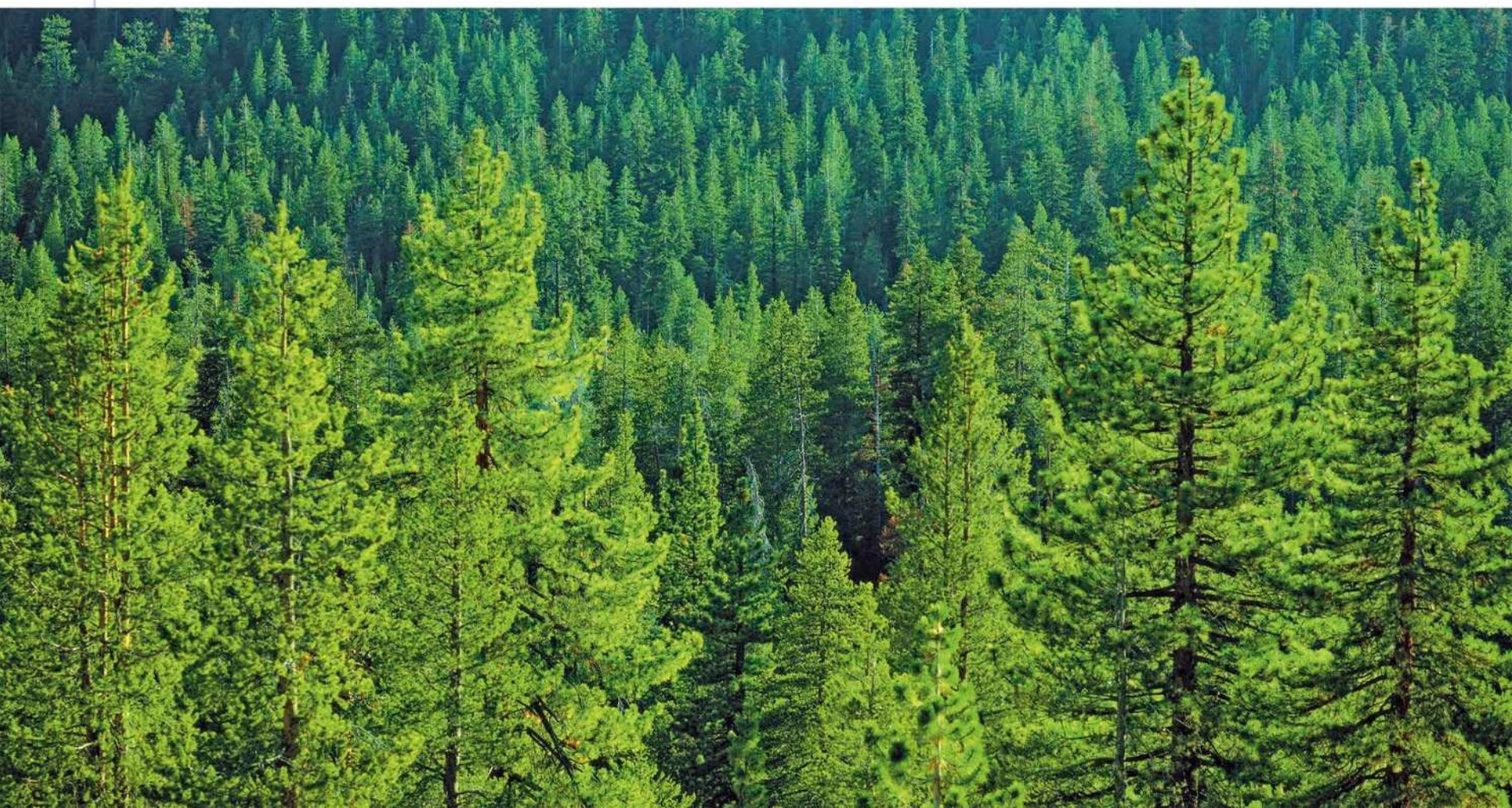
Most conifers are evergreen, with highly resinous leaves that are good at withstanding cold winds and strong sunshine. Pines have slender needles, arranged singly or in bundles, while other conifers often have linear leaves or flat scales. A few conifers – including larches and some redwoods – are deciduous, with soft leaves that are shed each year.

Conifers have two types of cone, which normally grow on the same tree. Male cones produce pollen. Small, soft, and often very numerous, they typically appear in spring, and wither soon after shedding their pollen into the air. The larger female cones contain one or more seeds. They can take several years to develop, and usually become hard and woody when mature.

The cones of some species, including firs and cedars, release their seeds by slowly disintegrating on the tree. Pine cones remain intact, and often remain on the tree long after they are ripe. Most of them shed their seeds in dry weather, when their scales open wide, but some hold onto their seeds until they are scorched. This is a specialized adaptation that allows pines to recolonize areas that have been burned by forest fires.

A few conifers, the yews, junipers, and podocarps, have small, berry-like cones with fleshy scales that do not fully enclose the seed. These are scattered by birds as they feed.

CONIFERS IN CONTROL
Conifers often form extensive single-species stands. These pines are growing in California's Yosemite National Park in the USA.



COLORADO SPRUCE
Picea pungens
F: Pinaceae

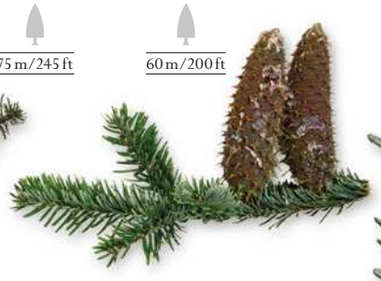
Bright blue-grey leaves, with prickly tips, make this a popular ornamental tree. Native to western N. America, it typically grows on mountains.

GIANT FIR
Abies grandis
F: Pinaceae

The giant fir is a tall, fast-growing tree that is native to western N. America. Its leaves have a citrus-like scent when crushed.

RED FIR
Abies magnifica
F: Pinaceae

This drought-resistant fir is found on dry mountain slopes in California. It has up-curved leaves and upright cones up to 20 cm (8 in) long.



EUROPEAN SILVER FIR
Abies alba
F: Pinaceae

Named after the silver bands on the underside of its leaves, this fir has upright resinous cones. They disintegrate in order to scatter their seeds.

CAUCASIAN FIR
Abies nordmanniana
F: Pinaceae

Originally from mountains in the Black Sea region, this is a popular Christmas tree in Europe because it retains its needles indoors.

SITKA SPRUCE
Picea sitchensis
F: Pinaceae

Thriving in cold, wet conditions, the sitka spruce is often grown as a forestry tree. It comes from the coastal belt of western N. America.

SINGLE-LEAF PINYON
Pinus monophylla
F: Pinaceae

Unique among pines, this species has leaves that grow singly, rather than in pairs or clusters. It comes from rocky slopes in Mexico and the American Southwest.

NORWAY SPRUCE
Picea abies
F: Pinaceae

An important timber tree, this fast-growing conifer has spiky leaves and cylindrical cones. Its natural range is N. and C. Europe.

SCOTS PINE
Pinus sylvestris
F: Pinaceae

Ranging from the British Isles to China, the Scots pine is the world's most widespread conifer after common juniper. Its upper branches have beautiful orange-red bark.

STONE PINE
Pinus pinea
F: Pinaceae

Prized for its edible seeds (pine nuts), this Mediterranean pine has large, oval cones, and an elegant umbrella-shaped outline when mature.

LODGEPOLE PINE
Pinus contorta
F: Pinaceae

Growing in coastal dunes and bogs, this N. American pine has paired leaves and prickly cones. The cones release their seeds after being scorched by fire.

MONTEREY PINE
Pinus radiata
F: Pinaceae

Originally restricted to a small area of California, this fast-growing pine is now widely planted for its timber, particularly in the southern hemisphere.

AROLLA PINE
Pinus cembra
F: Pinaceae

Found on European mountains, this slow-growing tree produces small cones that fall intact. Birds such as nutcrackers feed on the cones and disperse the seeds.

MARITIME PINE
Pinus pinaster
F: Pinaceae

Native to the W. Mediterranean, the maritime pine grows rapidly on poor sandy soils. It has glossy brown cones that are up to 20 cm (8 in) long.

AUSTRIAN PINE
Pinus nigra
F: Pinaceae

Tall, rangy, and open-crowned, this pine has long leaves arranged in pairs. Despite its name, it is widespread throughout Europe, typically growing on limestone.

CHINESE PINE
Pinus tabuliformis
F: Pinaceae

With age, this oriental pine develops a distinctive flat, spreading crown. It grows on mountains, and produces small egg-shaped cones.

»

DEODAR
Cedrus deodara
F: Pinaceae
Native to the W. Himalayas, this fast-growing cedar has branches that droop at their tips. Its cones are purple-brown when ripe.

DOUGLAS FIR
Pseudotsuga menziesii
F: Pinaceae
One of the world's tallest conifers, the Douglas fir grows in western N. America. Its cones have projecting bracts formed from modified scales.

WESTERN HEMLOCK
Tsuga heterophylla
F: Pinaceae
From western N. America, this is the largest hemlock. It thrives in cool, damp conditions, and can live to be over 1,000 years old.

GOLDEN LARCH
Pseudolarix amabilis
F: Pinaceae
Native to E. China, the golden larch turns brilliant yellow in autumn before losing its leaves. Its cones break up as they scatter their seeds.

ATLAS CEDAR
Cedrus atlantica
F: Pinaceae
This N. African cedar has short needles and upright barrel-shaped cones. When ripe, the cones slowly break up to release their seeds.

CEDAR OF LEBANON
Cedrus libani
F: Pinaceae
A majestic conifer with spreading branches, the cedar of Lebanon is now rare in the wild, but is widely planted as an ornamental tree.

JAPANESE LARCH
Larix kaempferi
F: Pinaceae
A deciduous tree – like all larches – this has soft leaves and persistent woody cones with downcurved scales. It grows on mountains in N. Japan.

MONKEY PUZZLE
Araucaria araucana
F: Araucariaceae
Originally from the mountains of Chile, this primeval-looking tree has spirally arranged, sharply pointed leaves. Mature trees develop an umbrella-like crown.

JAPANESE UMBRELLA PINE
Sciadopitys verticillata
F: Sciadopityaceae
The only member of its family, this ancient Japanese species is distinguished from other conifers by having 10–13 needles clustered in whorls.

WESTERN RED-CEDAR
Thuja plicata
F: Cupressaceae
A large tree with flat sprays of small, scale-like leaves, this species grows in northwest N. America. Its wood is highly rot-resistant, even when dead.

LAWSON CYPRESS
Chamaecyparis lawsoniana
F: Cupressaceae
Like other cypresses, this has small cones and sprays of tiny, scale-like leaves. Originally from western N. America, it exists in many cultivated forms.

JAPANESE CEDAR
Cryptomeria japonica
F: Cupressaceae
A cypress rather than a true cedar, this tree has slender leaves and small, rounded cones. It grows on mountains in China and Japan.

WESTERN JUNIPER
Juniperus occidentalis
F: Cupressaceae
This long-lived tree grows on rocky mountain slopes in W. USA. Like other junipers, it produces seeds inside berry-like cones.

CHINESE JUNIPER
Juniperus chinensis
F: Cupressaceae
Widespread in temperate E. Asia, this shrub or small tree has prickly leaves when young, and scale-like leaves when mature.

COAST REDWOOD
Sequoia sempervirens
F: Cupressaceae
Native to the coasts of N. California and Oregon, this is the world's tallest tree. Mature trees have a soaring trunk and relatively sparse branches, and can be as much as 2,000 years old.

GIANT SEQUOIA
Sequoiadendron giganteum
F: Cupressaceae
This Californian redwood is the world's most massive tree. The largest living specimen is estimated to weigh 2,000 tonnes, with fireproof bark over 60 cm (2 ft) thick.

DAWN REDWOOD
Metasequoia glyptostroboides
F: Cupressaceae
Native to C. China, this deciduous redwood is extremely rare in the wild. Until the 1940s it was thought to be extinct, being known only from fossils.

MONTEREY CYPRESS
Cupressus macrocarpa
F: Cupressaceae
Although widely cultivated, the wild Monterey cypress is restricted to a small region of California's coast. Mature trees typically have an irregular spreading shape.

TAIWANIA
Taiwania cryptomerioides
F: Cupressaceae
One of Asia's largest conifers, this tropical species has a trunk up to 3 m (10 ft) thick. It has spiny-tipped leaves, and small, rounded cones.

SWAMP CYPRESS
Taxodium distichum
F: Cupressaceae
Also known as the bald cypress, this deciduous conifer grows in swamps in S.E. USA. Its trunk often has a buttressed base.

CALIFORNIA NUTMEG
Torreya californica
F: Taxaceae
This rare conifer is restricted to canyons and mountains in California. It is unrelated to the true nutmeg, although it has nut-like seeds.

CHINESE PLUM-YEW
Cephalotaxus fortunei
F: Taxaceae
This small, densely branched conifer has fleshy cones, which turn purple-brown when ripe. It grows in mountain forests in C. and E. China.

EUROPEAN YEW
Taxus baccata
F: Taxaceae
This long-lived tree produces seeds in fleshy arils – modified cone scales. Found wild in Europe and S.W. Asia, it is commonly planted.

FLOWERING PLANTS

With over 300,000 species, flowering plants – or angiosperms – are by far the largest group of plants, as well as the most diverse. They play a vital role in most land-based ecosystems, producing food and shelter for animals and many other living things.

DIVISION	ANGIOSPERMAE
CLADES	10
ORDERS	64
FAMILIES	416
SPECIES	About 304,000

Wind-pollinated flowers such as hazel catkins shed clouds of pollen grains into the air. They are rarely brightly coloured.

Animal-pollinated flowers are usually conspicuous, and have sticky pollen grains. Hummingbirds transfer pollen as they feed.

Fleshy fruits evolved to attract animals. Wild cucumbers are eaten by antelopes, which scatter the seeds in their droppings.

Dry fruits often burst open when their seeds are ripe. This willowherb is scattering its fluffy seeds into the wind.

The first flowering plants evolved 140 million years ago, which makes them relative latecomers to life on Earth. Since then, they have become the dominant forms of plant life. The smallest flowering plants are not much bigger than a pinhead, but this group also includes all broadleaved trees, and a variety of other species, from cacti and grasses to orchids and palms.

Flowering plants share several key features that help to make them successful. Foremost among these are flowers – actually a collection of highly modified leaves. In most flowers, the outermost layers are the sepals, then the petals. These surround the male stamens, which make pollen, and the female carpels, which collect pollen arriving from similar flowers, so that their female ovules can develop into seeds. Some flowers spread their pollen through the air, but many more use animals to transfer pollen for them. In these showy species, flowers lure animals to sip the sugary nectar in the innermost part of the flower, brushing past the pollen on the way. These plants mostly attract insects, but birds and bats are also important pollinators.

STRATEGIES FOR SPREADING

Flowering plants are not unique in making seeds, but they are the only plants that produce them in fruits. A fruit develops from a flower's ovaries – the closed chambers that house the seeds, close to the flower's central stem. Fruits have a double function: to protect the seeds and to help them spread. Fleshy fruits do this by attracting animals, which feed and scatter the seeds in their excrement. Dry fruits work in a variety of ways. Some burst open when their seeds are ripe. Others have hooks that latch onto clothing, skin, or fur. Still more drift in water or through the air. Many flowering plants spread by the way they grow, often producing new plants from creeping stems. This can create vast, interconnected clones. The largest examples, formed by North American aspen trees, stretch over 40 ha (100 acres), and may be 10,000 years old.

ATTRACTING ATTENTION >
Hellebores use colourful sepals, rather than petals, to attract pollinating insects – or multiple sepals in this garden variety.

FLOWERING PLANTS GROUPS

DNA sequencing is revolutionizing our understanding of relationships between flowering plants. The groupings below represent current thinking (see p.150 for subdivisions within the Eudicots).

BASAL ANGIOSPERMS
» 124

MAGNOLIIDS
» 128

MONOCOTS
» 130

EUDICOTS
» 150

BASAL ANGIOSPERMS

Of the more than 60 orders of flowering plants, or angiosperms, three, known as basal angiosperms, evolved early on and still exist today.

Modern DNA sequencing is a powerful way of identifying groups of species that are closely related to one another. However, the interrelationship between these groups is sometimes less clear, with different DNA markers suggesting different affinities. In flowering plants, there seems to be a pattern of some flourishing groups that have diversified hugely, leaving behind a few, remnant groups that have survived for millions of years but diversified little.

"Basal angiosperm" is the term used for three of these remnant orders. They are primitive species, apparently with little in common, growing in widely scattered parts of the world. They include trees, shrubs, and climbers, as well as water plants. The Amborellales order survives today as a single species of shrub on one South Pacific island. The Nymphaeales are aquatic plants with primitive but often showy flowers. They include over 70 species of water lilies, found all over the globe. The Austrobaileyales order contains nearly 100 species of woody plants, mainly in the tropics.

Two other orders feature on this page as "orphans", whose place in the phylogeny (evolutionary history) of angiosperm families is unclear. The most recent review suggests that the Chloranthales might be related to magnoliids, and the Ceratophyllales to eudicots, but for now that remains uncertain and unproven.

DIVISION	ANGIOSPERMAE
GROUPS	BASAL ANGIOSPERMS
ORDERS	3
FAMILIES	7
SPECIES	190

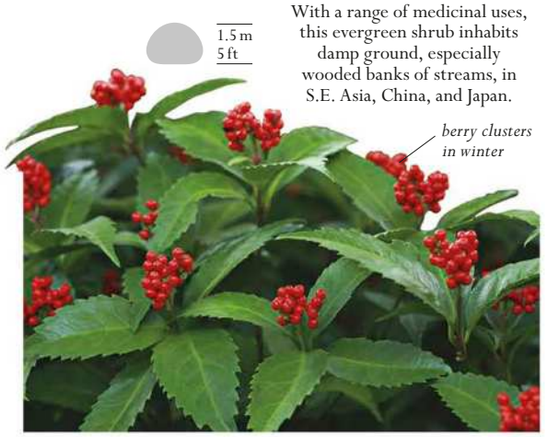
DEBATE

MYSTERIOUS ORIGINS

Angiosperms may have evolved from seed ferns, a group that died out over 50 million years ago, or more probably from gnetophytes (see p.117). DNA and fossil evidence suggest that the Amborellales were the first angiosperms to appear, around 140 million years ago. The Nymphaeales and Austrobaileyales were the next two groups to evolve.

CHLORANTHALES

The Chloranthaceae, the only family in the order Chloranthales, contains four genera and around 70 living species, but its fossil record dates back over 100 million years. Its members are mainly tropical shrubs and trees with small, stalkless flowers.

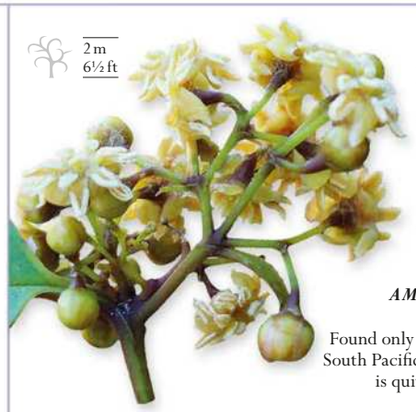


SARCANDRA GLABRA
F: Chloranthaceae
With a range of medicinal uses, this evergreen shrub inhabits damp ground, especially wooded banks of streams, in S.E. Asia, China, and Japan.

CERATOPHYLLALES

A single family, the Ceratophyllaceae, makes up this order. Called hornworts, these plants are completely unrelated to the non-flowering hornworts (see p.111). The four species are free-floating, rootless aquatics with whorls of finely-divided leaves, tiny male and female flowers, and spiny fruits.

RIGID HORNWORT
Ceratophyllum demersum
F: Ceratophyllaceae
This is a submerged species with no roots, inhabiting ponds and ditches in non-arctic Europe. It has tiny flowers and whorls of leaves.



AMBORELLALES

This order of primitive evergreen shrub contains a single family, which has a single genus with only one species, *Amborella trichopoda*. It bears small flowers, males and females being produced on separate plants, and red berries, each containing a single seed.

AMBORELLA TRICHOPODA
F: Amborellaceae
Found only on the island of New Caledonia in the South Pacific, this sprawling, white-flowered shrub is quite common in mountain forests.

AUSTROBAILEYALES

The order Austrobaileyales is made up of only three families. Members of this order are trees, shrubs, and climbers. The flowers of most species are single and have many petals. Perhaps the best known species is the spice, star anise.

AUSTROBAILEYA SCANDENS
F: Austrobaileyaceae
The flowers of this rare primitive climber, found only in rainforests in Queensland, Australia, smell of rotting fish to attract pollinating flies.

STAR ANISE
Illicium verum
F: Schisandraceae
Widely used for flavouring, star anise fruits are woody and star-shaped. This woodland species is native to China and Vietnam.

NYMPHAEALES

This primitive order encompasses three families of aquatic plants with floating, submerged, or, more rarely, emergent leaves. The family Nymphaeaceae includes water lilies, which are grown in ornamental ponds throughout the world for their showy flowers.

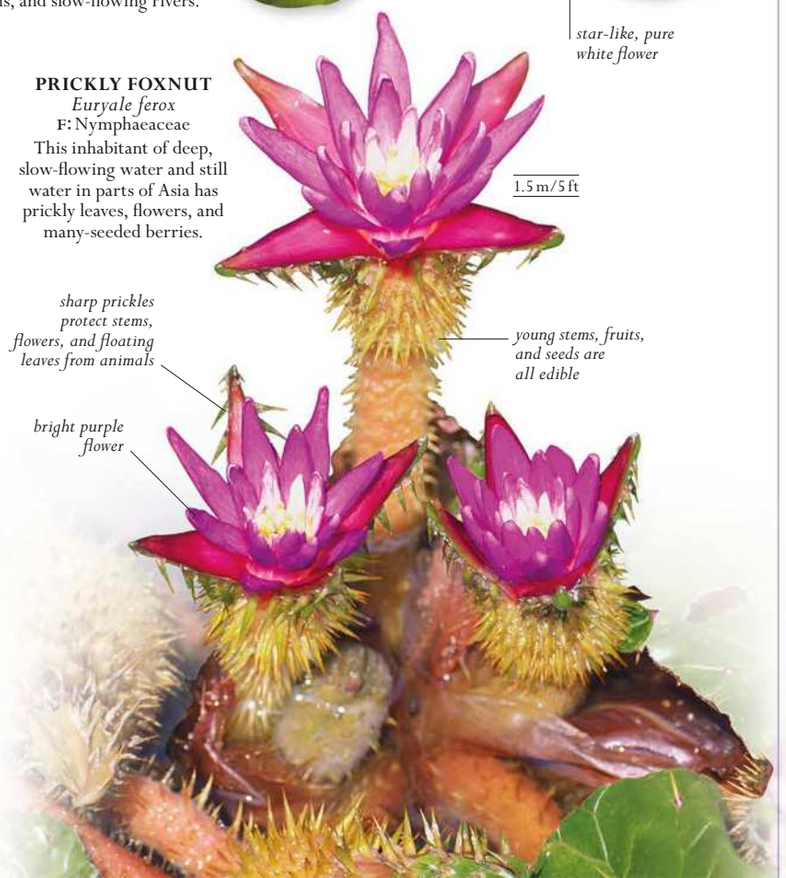
AMAZON WATER LILY
Victoria amazonica
F: Nymphaeaceae
Native to deep Amazonian backwaters, this water lily has enormous round leaves with upright rims. The flowers open at night.

***NYMPHAEA* 'SUNRISE'**
F: Nymphaeaceae
With large, showy, fragrant flowers and mid-green floating foliage, this hybrid, thought to be of American origin, is one of the largest flowering water lilies.

CAROLINA FANWORT
Cabomba caroliniana
F: Cabombaceae
From still, freshwater habitats in USA and S.E. South America, this species has submerged and floating leaves. It can be invasive.

WHITE WATER LILY
Nymphaea alba
F: Nymphaeaceae
This European species has fragrant flowers and its fruits ripen under water, releasing floating seeds. It inhabits lakes, ponds, and slow-flowing rivers.

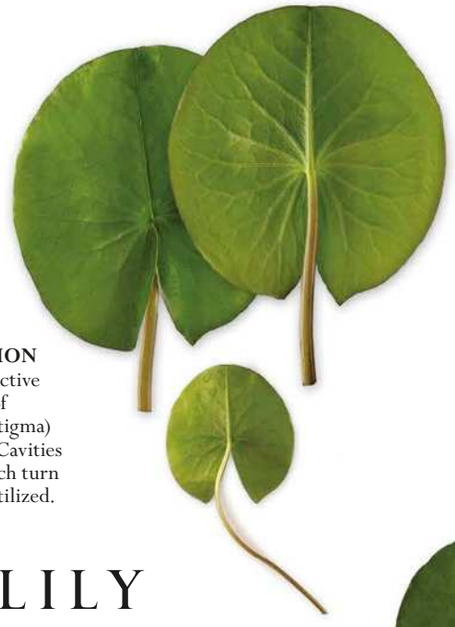
PRICKLY FOXNUT
Euryale ferox
F: Nymphaeaceae
This inhabitant of deep, slow-flowing water and still water in parts of Asia has prickly leaves, flowers, and many-seeded berries.

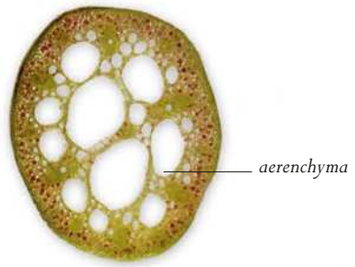

1.5 m/5 ft
sharp prickles protect stems, flowers, and floating leaves from animals
young stems, fruits, and seeds are all edible
bright purple flower

∨ FLOATING FLOWERS
Water lily flowers are hermaphrodite – they have both male and female organs. Pollen from the male parts can fertilize ovules in the female reproductive parts, so they can "self-pollinate". However, female parts mature slightly before the flower starts releasing pollen. This increases the chances of flowers being fertilized by pollen carried by insects.

∧ FLOWER
The flowers have numerous white petals and bright yellow stamens, and can grow to 20 cm (8 in) in diameter.

∨ LEAVES
The water lily has large leaves, up to 35 cm (14 in) in diameter. Unlike most leaves, their stomata (breathing pores) are on the upper surface, which has a water-repellent coating.





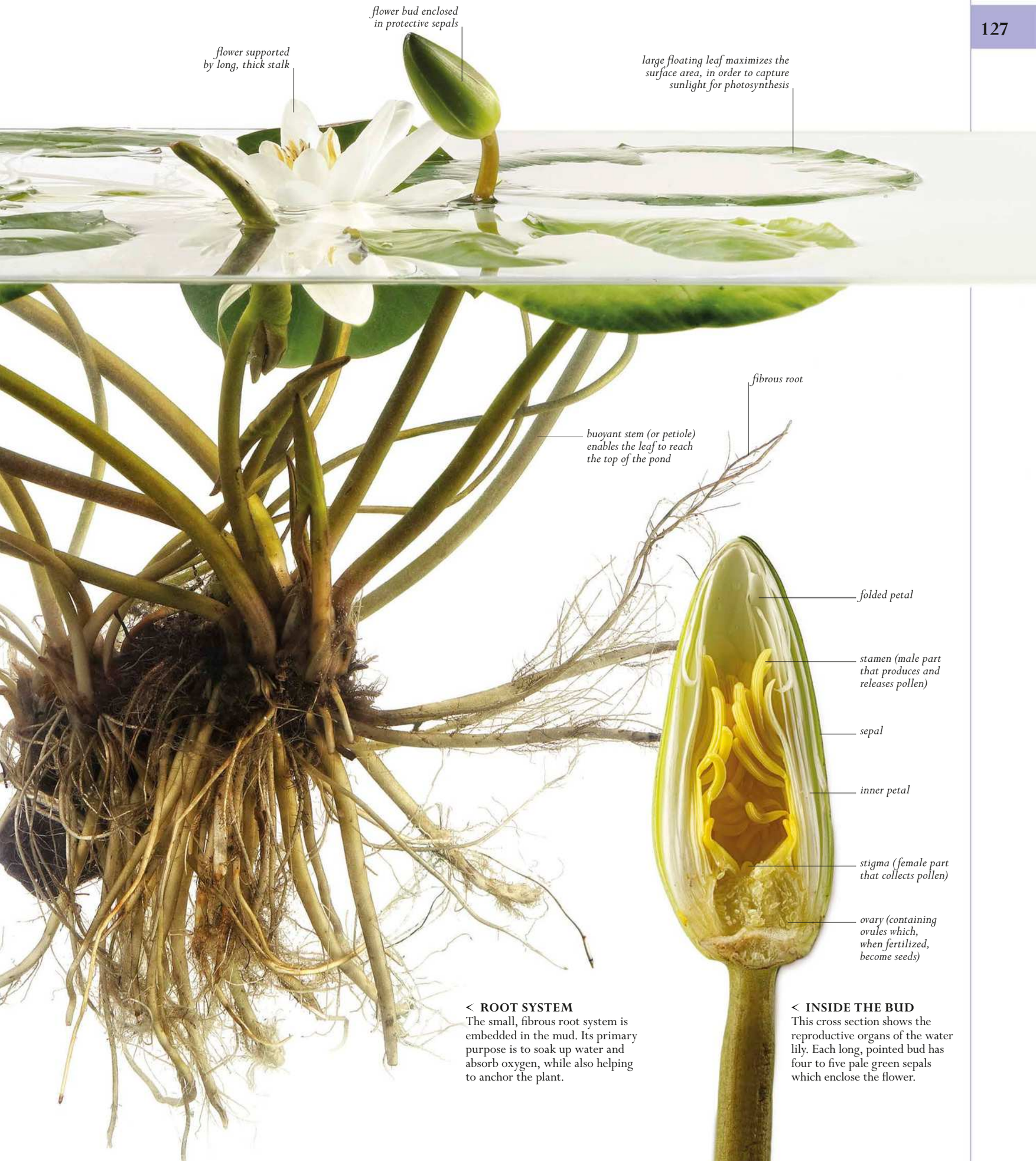
∧ STEM SECTION
Stems have longitudinal air spaces (aerenchyma), as well as structural tissue, creating buoyancy and allowing oxygen to circulate.

< OVARY SECTION
The female reproductive organs (consisting of ovules, ovary, and stigma) are fused together. Cavities contain ovules, which turn into seeds when fertilized.

WHITE WATER LILY
Nymphaea alba

One of about 75 wild species of water lily, this handsome plant lives in still or slow-flowing water, casting a deep shade with its rounded, glossy leaves. It grows in water up to 1.5 m (5 ft) deep, and flowers in mid- to late summer, producing a succession of pure white blooms. Each flower lasts for three to four days, opening in the morning and closing by late afternoon. They attract pollinating beetles, which often spend the night inside the flowers, before being released at dawn. White water lilies are useful to water animals: pond snails glue their eggs to the underside of the leaves, and fish hide beneath them, avoiding predatory birds. After the flowers are pollinated, they produce buoyant seeds. These float for several weeks, before sinking into the mud.

SIZE Leaf diameter 10–35 cm (4–14 in)
HABITAT Ponds, streams, lakes, backwaters
DISTRIBUTION Europe
LEAF TYPE Simple, orbicular with a basal notch


flower bud enclosed in protective sepals
flower supported by long, thick stalk
large floating leaf maximizes the surface area, in order to capture sunlight for photosynthesis
fibrous root
buoyant stem (or petiole) enables the leaf to reach the top of the pond
folded petal
stamen (male part that produces and releases pollen)
sepal
inner petal
stigma (female part that collects pollen)
ovary (containing ovules which, when fertilized, become seeds)

< ROOT SYSTEM
The small, fibrous root system is embedded in the mud. Its primary purpose is to soak up water and absorb oxygen, while also helping to anchor the plant.

< INSIDE THE BUD
This cross section shows the reproductive organs of the water lily. Each long, pointed bud has four to five pale green sepals which enclose the flower.

MAGNOLIIDS

The magnoliids are a large group of primitive flowering plants that in botanical terms are between basal angiosperms and monocots.

Found in tropical and temperate regions, the magnoliids form a major plant group that emerged early in the history of flowering plants. They take their name from the magnolia family, which is one of the largest in the group. Plants in this family nearly all have woody stems, and some kinds grow into large trees. However, the group also includes herbaceous or non-woody species, both as free-standing plants and as climbers.

Some herbaceous magnoliids have highly specialized flowers. In birthworts and pipevines, for example, the flower is shaped like a flaring tube, lined with backward-pointing hairs. Flowers like these act as temporary traps for pollinating flies, which are attracted by a powerful scent. But these are an exception. Most magnoliid flowers are structurally simple, with numerous spirally arranged parts, attached separately to a central stem. Instead of sepals and petals (see p.122), they have a single layer of flaps that are similar in colour, size, and shape, known as tepals. The fossil record shows that similar flowers existed over 100 million years ago.

COMMON CHARACTERISTICS

Magnoliids are grouped together mainly by genetic evidence, but they also share features that can be seen with a microscope, or with the naked eye. At a microscopic level, their pollen grains have a single pore. This small but significant feature links them with monocots, but distinguishes them from eudicots – by far the largest group of flowering plants – which have three-pored pollen grains.

Most magnoliids have leaves with smooth margins, and a network of branching veins. Their fruits may be soft and fleshy, or hard and cone-like, and can contain one or several seeds. Species with fleshy fruits use animals to disperse their seeds: many of them are swallowed whole and then scattered by birds. In prehistoric times, wild avocados may have been dispersed by giant ground sloths. Now that ground sloths are extinct, avocados depend on human cultivation to disperse their seeds and ensure survival.

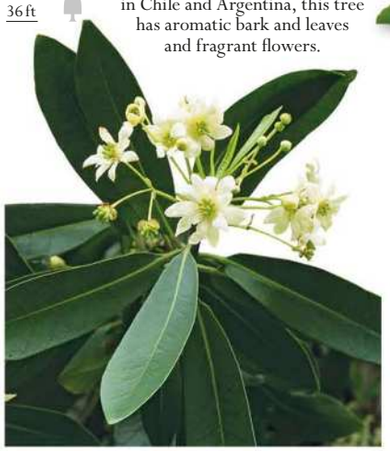
DIVISION	ANGIOSPERMAE
CLADE	MAGNOLIIDAE
ORDERS	4
FAMILIES	18
SPECIES	10,000

DEBATE
PIONEERING PLANTS

Scientists have differing opinions about the growth habit, or shape and lifestyles, of the first flowering plants. According to the "woody hypothesis", these plants were trees or shrubs, like many magnoliids are today. However, a rival view – known as the "paleoherb hypothesis" – suggests that the first angiosperms were herbaceous, or non-woody, plants with relatively fast life cycles. This meant that they were good at colonizing disturbed ground such as riverbanks. Currently, neither view has proved decisive, although molecular analysis does favour the idea that they were woody plants.

CANELLALES

There are two families in the order Canellales: the Canellaceae and the Winteraceae. These are aromatic trees and shrubs with leathery entire leaves. The flowers in most species have both male and female parts and the fruit is a berry. The leaves and bark of some species can be used medicinally. The Winteraceae is a primitive family – its members have woody stems that contain no water-conducting vessels.



WINTER'S BARK
Drimys winteri
F: Winteraceae
Native to the coastal rainforest in Chile and Argentina, this tree has aromatic bark and leaves and fragrant flowers.

PIPERALES

The order Piperales includes three families of herbaceous plants, trees, and shrubs, widely distributed in tropical regions. The stems have scattered bundles of vascular tissue, a characteristic of monocots. Members of the family Piperaceae have tiny flowers which lack petals and are clustered in spikes. Many species are aromatic.

BIRTHWORT
Aristolochia clematitis
F: Aristolochiaceae
A foul-smelling and poisonous perennial, birthwort was grown for medicinal use. It is native to Europe, growing in damp places.

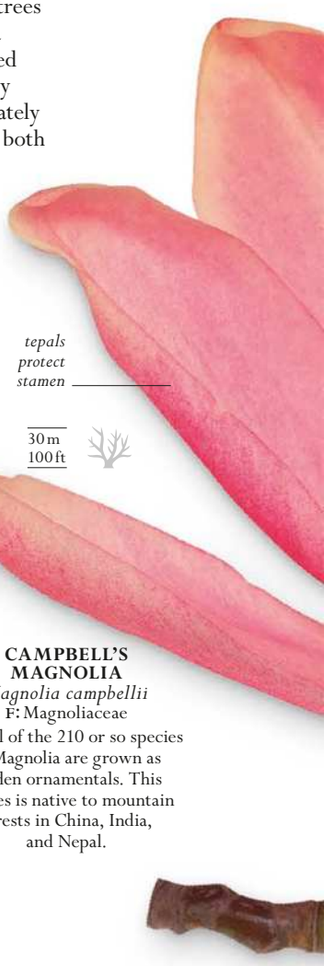
ASARABACCA
Asarum europaeum
F: Aristolochiaceae
This creeping species grows in European woodlands. Its glossy evergreen leaves hide insignificant flowers.

BLACK PEPPER
Piper nigrum
F: Piperaceae
An evergreen climber from shady habitats in S. India and Sri Lanka, this species is widely cultivated for its aromatic fruits.

MAGNOLIALES

Consisting almost exclusively of trees and shrubs, the Magnoliales are a primitive order, widely distributed in the fossil record. Although very variable, most have simple alternately arranged leaves and flowers with both male and female parts. There are six families in the order, of which the Magnoliaceae are the best known, being widely grown in gardens for their spectactular flowers.

TULIP TREE
Liriodendron tulipifera
F: Magnoliaceae
A native of eastern N. America, the tulip tree grows in woodland. The leaves turn yellow in autumn before falling.



CAMPBELL'S MAGNOLIA
Magnolia campbellii
F: Magnoliaceae
Several of the 210 or so species of Magnolia are grown as garden ornamentals. This species is native to mountain forests in China, India, and Nepal.

LAURALES

The order Laurales consists of seven families of trees, shrubs, and woody climbing plants. A few genera grow in temperate parts of the world, but most are found in tropical and subtropical regions. Their classification is based on genetic analysis rather than morphological characteristics. Many plants are aromatic and are used in perfumery, cookery, and medicine. Others provide timber or are grown ornamentally.

BAY LAUREL
Laurus nobilis
F: Lauraceae
Widely cultivated for its aromatic leaves used in flavouring, this species grows in woods, scrub, and rocky habitats around the Mediterranean.

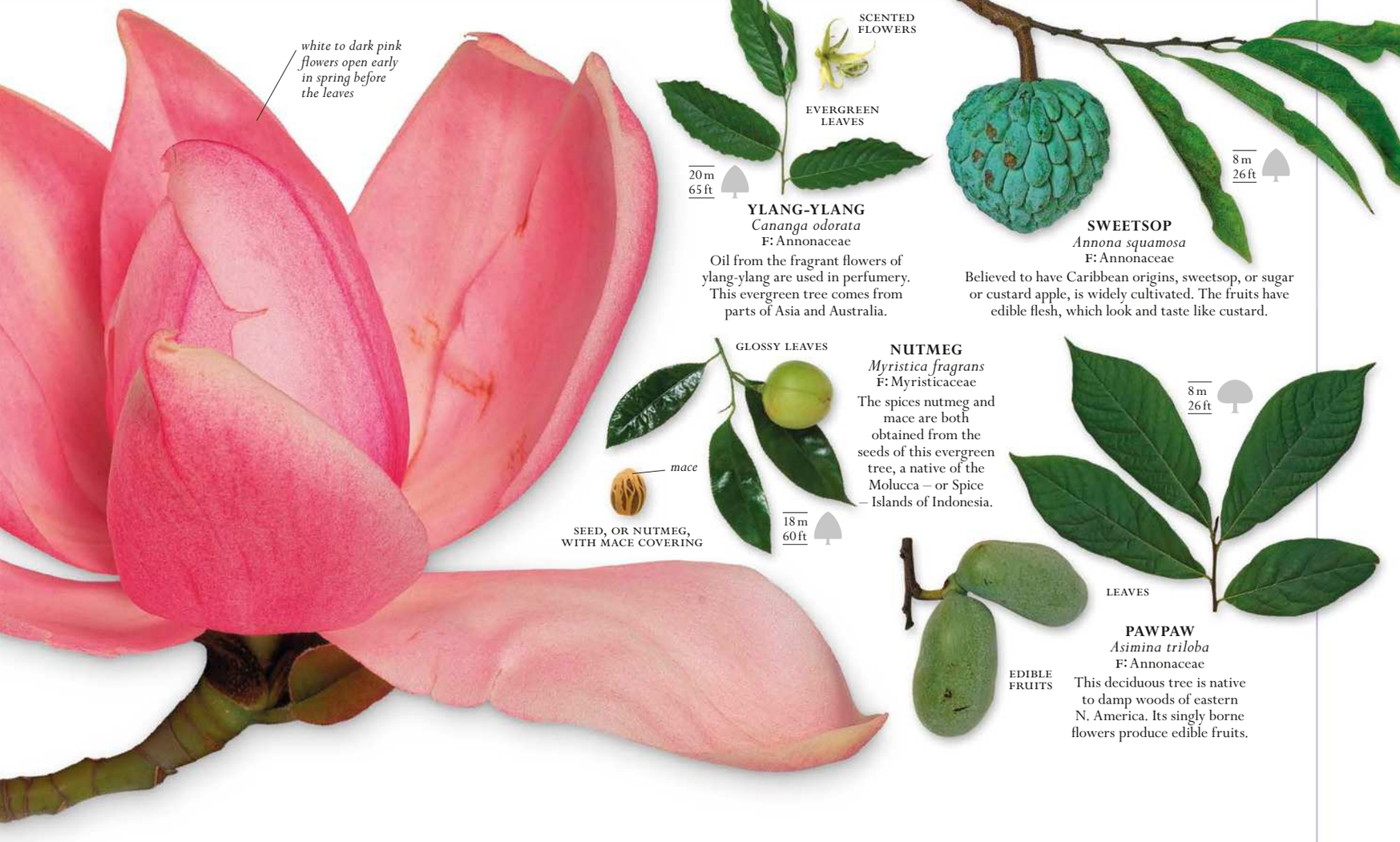
SASSAFRAS
Sassafras albidum
F: Lauraceae
This suckering deciduous tree of woodland in eastern N. America has aromatic leaves which are brightly coloured in autumn.

CAROLINA ALLSPICE
Calycanthus floridus
F: Calycanthaceae
Native to woods and streamsides in S.E. USA, Carolina allspice has aromatic leaves and bark and large, fragrant flowers.

CINNAMON
Cinnamomum verum
F: Lauraceae
The spice cinnamon comes from the aromatic bark of this species, found in lowland forests in Sri Lanka.

CALIFORNIA LAUREL
Umbellularia californica
F: Lauraceae
Sometimes called "headache tree", as scent from the crushed leaves can cause headaches, this species from W. USA flowers in winter.

AVOCADO TREE
Persea americana
F: Lauraceae
Probably originating in S. Mexico, in well-drained parts of rainforests, the avocado tree is now widely cultivated for its edible pear-shaped fruits.



YLANG-YLANG
Cananga odorata
F: Annonaceae
Oil from the fragrant flowers of ylang-ylang are used in perfumery. This evergreen tree comes from parts of Asia and Australia.

SWEETSOP
Annona squamosa
F: Annonaceae
Believed to have Caribbean origins, sweetsop, or sugar or custard apple, is widely cultivated. The fruits have edible flesh, which look and taste like custard.

NUTMEG
Myristica fragrans
F: Myristicaceae
The spices nutmeg and mace are both obtained from the seeds of this evergreen tree, a native of the Molucca – or Spice – Islands of Indonesia.

PAWPAW
Asimina triloba
F: Annonaceae
This deciduous tree is native to damp woods of eastern N. America. Its singly borne flowers produce edible fruits.

MONOCOTS

Defined by their unique internal anatomy, monocots include grasses and palms, plus lilies, orchids, and many other ornamental plants.

Early in the evolution of flowering plants, their family tree developed two major branches. A smaller but still substantial branch became the monocots, while the larger branch became the eudicots. Monocots get their name from their seeds, which have a single pre-packed seed-leaf, or cotyledon. Apart from this, there is no foolproof way of recognizing a monocot, although there are strong clues. Most have long, narrow leaves with parallel veins, and the flower parts (petals, stamens, and so on) are arranged in threes or multiples of three. The pollen grains have a single opening, unlike those of eudicots which have three. In many monocot flowers, such as tulips, the sepals and petals are almost identical and are known as tepals, but many magnoliids share this feature.

Below ground, monocots usually have a cluster of fibrous roots, instead of a main taproot with smaller roots leading off it. Another key characteristic – revealed under a microscope – involves the structure of their stems. Monocots have scattered bundles of vascular tissue – the specialized cells that carry water and sap – unlike eudicots, which have theirs in concentric rings. This makes monocot stems more flexible than those of a typical eudicot, but it also makes it harder for them to evolve into trees. Tree-like monocots, which principally include palms, have a very different way of growing to typical broadleaved trees and conifers. Monocot trunks grow taller, but not thicker, and are usually topped by a single rosette of leaves.

SURVIVAL STRATEGIES

Smaller monocots vary greatly, from climbers to aquatic plants that survive harsh periods as underground storage organs, such as bulbs or tubers. Grasses thrive on the grazing effects of animals, and are the only plant family that forms an entire habitat: grassland. In the tropics, many monocots are epiphytic, growing high up in trees. This group includes bromeliads, and many orchids – by far the largest monocot family, with over 25,000 species worldwide.

DIVISION	ANGIOSPERMAE
CLADE	MONOCOTS
ORDERS	11
FAMILIES	77
SPECIES	60,000

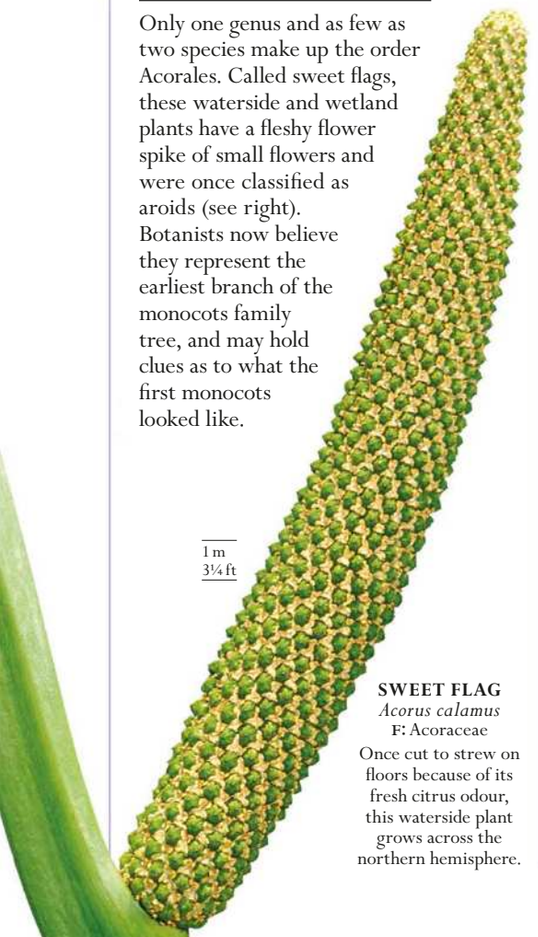
DEBATE

DID MONOCOTS HAVE AQUATIC ORIGINS?

Living monocots include many freshwater plants, and also some of the few flowering plants that live in the sea. According to a longstanding theory, monocots may have originally evolved in fresh water, before diversifying and taking up life on land. This would account for the long, thin leaves found in many species, and also the internal structure of their stems (see left). Having spread to land, some terrestrial monocots then came full circle and evolved into aquatic forms – duckweeds, for example, originated in this way.

ACORALES

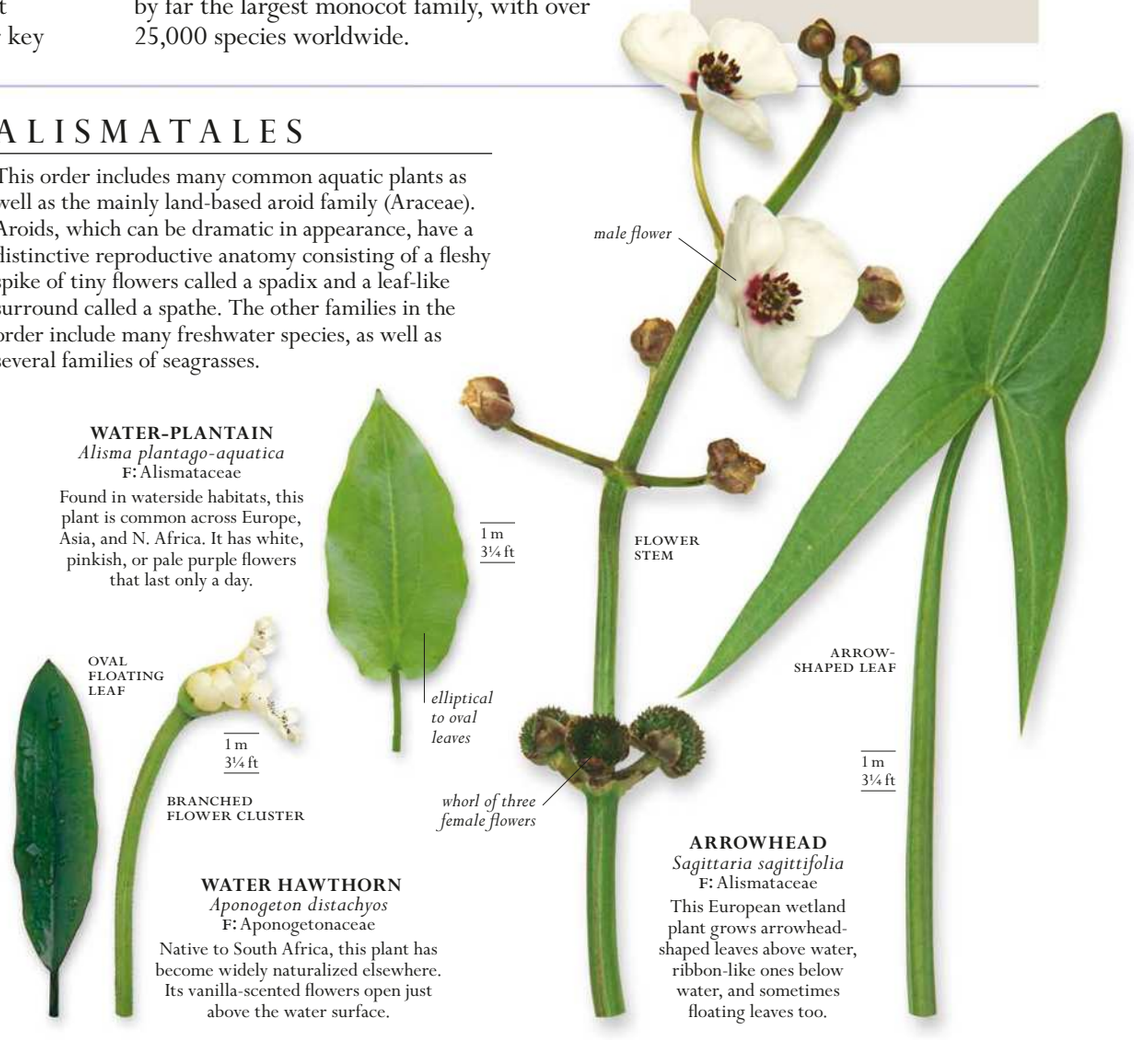
Only one genus and as few as two species make up the order Acorales. Called sweet flags, these waterside and wetland plants have a fleshy flower spike of small flowers and were once classified as aroids (see right). Botanists now believe they represent the earliest branch of the monocots family tree, and may hold clues as to what the first monocots looked like.



SWEET FLAG
Acorus calamus
F: Acoraceae
Once cut to strew on floors because of its fresh citrus odour, this waterside plant grows across the northern hemisphere.

ALISMATALES

This order includes many common aquatic plants as well as the mainly land-based aroid family (Araceae). Aroids, which can be dramatic in appearance, have a distinctive reproductive anatomy consisting of a fleshy spike of tiny flowers called a spadix and a leaf-like surround called a spathe. The other families in the order include many freshwater species, as well as several families of seagrasses.



WATER-PLANTAIN
Alisma plantago-aquatica
F: Alismataceae
Found in waterside habitats, this plant is common across Europe, Asia, and N. Africa. It has white, pinkish, or pale purple flowers that last only a day.

ARROWHEAD
Sagittaria sagittifolia
F: Alismataceae
This European wetland plant grows arrowhead-shaped leaves above water, ribbon-like ones below water, and sometimes floating leaves too.

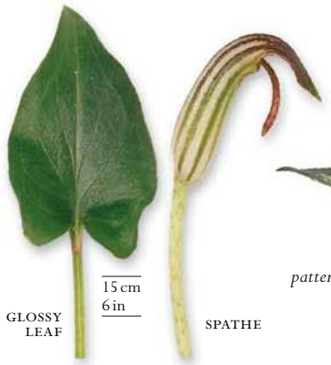
WATER HAWTHORN
Aponogeton distachyos
F: Aponogetonaceae
Native to South Africa, this plant has become widely naturalized elsewhere. Its vanilla-scented flowers open just above the water surface.

GIANT TARO
Alocasia macrorrhizos
F: Araceae

Native from tropical Malaysia to Queensland, Australia, this huge-leaved aroid is cultivated around the Pacific region as an ornamental and minor food crop.

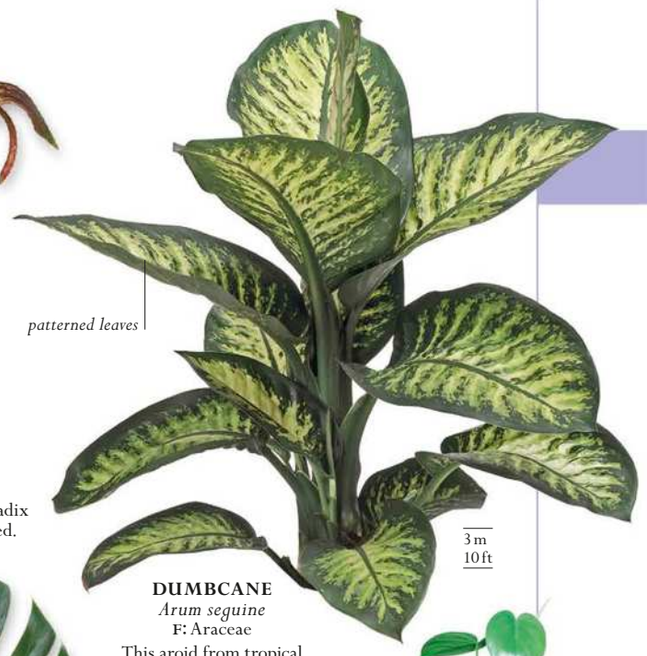
LORDS AND LADIES
Arum maculatum
F: Araceae

The spadix of this spring-flowering European native heats up to attract pollinating insects. In the autumn it produces poisonous red berries.



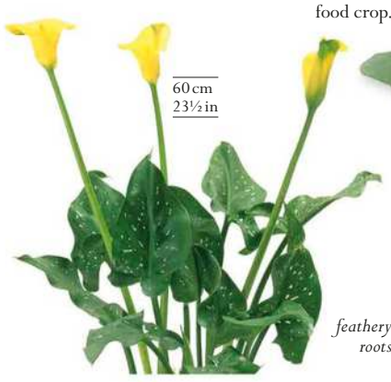
FRIAR'S COWL
Arisarum vulgare
F: Araceae

The spathe of this widespread Mediterranean aroid curves over its spadix like a hood. Its leaves are arrow-shaped.



DUMBCANE
Arum seguine
F: Araceae

This aroid from tropical American forests causes severe swelling and pain if chewed. Houseplant varieties have showy, attractive foliage.



GOLDEN ARUM
Zantedeschia elliottiana
F: Araceae

This showy aroid with yellow spathes is found only in cultivation. Its wild relatives live in South Africa, mainly in wetland habitats.

WATER LETTUCE
Pistia stratiotes
F: Araceae

Of uncertain origin, this lettuce-sized member of the aroid family floats in warm fresh waters worldwide, often clogging waterways.

SWISS CHEESE PLANT
Monstera deliciosa
F: Araceae

The mature leaves of this tree-climbing aroid from C. America become perforated and divided. Swiss cheese plant is widely grown as a houseplant.

SWEETHEART PLANT
Philodendron scandens
F: Araceae

Very common in its native C. America, this fast-growing climbing aroid is also a popular ornamental houseplant.

FAT DUCKWEED
Lemna gibba
F: Araceae

Despite appearances, duckweed belongs to the aroid family. This widespread floating plant grows in tiny ovals up to 5 mm across.

SPOTLESS WATERMEAL
Wolffia arhiza
F: Araceae

Found worldwide, this rootless duckweed is the world's smallest flowering plant, forming tiny green ovals only 1 mm wide.

TITAN ARUM
Amorphophallus titanum
F: Araceae

After its 3 m (10 ft) flower stalk has died down, this giant aroid from Sumatra grows a single, long-lasting, tree-like leaf.

TARO
Colocasia esculenta
F: Araceae

This large-leaved aroid, native to tropical Asia and the Pacific, has been cultivated extensively since ancient times for its edible tubers.

DRAGON ARUM
Dracunculus vulgaris
F: Araceae

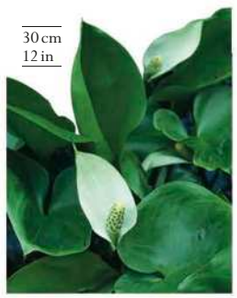
With its dark red spathe and odour of rotting meat, this E. Mediterranean aroid is well adapted to attract pollinating flies.

COBRA LILY
Arisaema consanguineum
F: Araceae

Native from the E. Himalayas to China, this summer-flowering aroid has a distinctive striped spathe. The whole plant is very poisonous.

WESTERN SKUNK CABBAGE
Lysichiton americanus
F: Araceae

Native to wet habitats in western N. America, this aroid gives off a strong odour to attract insects.



BOG ARUM
Calla palustris
F: Araceae

This wetland and shallow-water aroid is a popular ornamental. It is native to cool regions of the northern hemisphere.

FLOWERING RUSH
Butomus umbellatus
F: Butomaceae

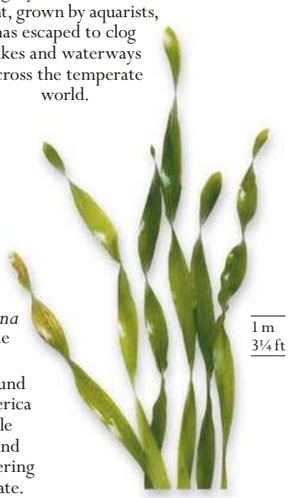
A showy waterside plant, flowering rush is the only member of its family native to Eurasia. It is invasive in N. America.

» ALISMATALES

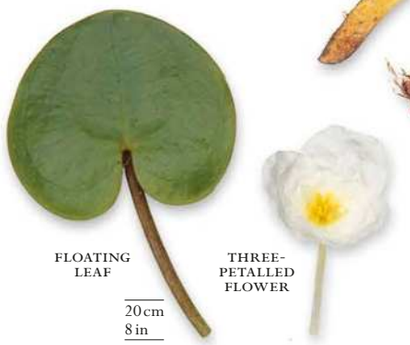
SOUTH AMERICAN WATERWEED
Egeria densa
F: Hydrocharitaceae
Native from Brazil to Uruguay, this underwater plant, grown by aquarists, has escaped to clog lakes and waterways across the temperate world.

BROAD-LEAVED PONDWEED
Potamogeton natans
F: Potamogetonaceae
This freshwater plant has broad surface leaves and grass-like underwater ones. It is common across the northern hemisphere.

NEPTUNE GRASS
Posidonia oceanica
F: Posidoniaceae
This seagrass sometimes forms dense patches on sandy seabeds, at depths of up to 35 m (115 ft) beneath the Mediterranean Sea.



TAPE GRASS
Vallisneria americana
F: Hydrocharitaceae
This submerged, freshwater plant is found from southern N. America to Colombia. Its male flowers break loose and float, perhaps encountering female ones to pollinate.



FROGBIT
Hydrocharis morsus-ranae
F: Hydrocharitaceae
This free-floating freshwater plant from Eurasia spreads via horizontal underwater stems. Male and female flowers grow on separate plants.

COMMON EELGRASS
Zostera marina
F: Zosteraceae
Growing on sandy sea floors across the northern hemisphere, this grass-like plant forms underwater "meadows" that are an important marine habitat.

ASPARAGALES

This diverse order of 14 families includes familiar garden flowers such as daffodils and irises, desert-adapted plants such as agaves, and a few trees. Some of its members were previously classified in the order Liliales, but modern genetic techniques have changed our understanding of these interrelationships. The order also includes the highly specialized orchid family.

ROUND-HEADED LEEK
Allium sphaerocephalon
F: Amaryllidaceae
This European relative of the onion favours limestone soils. Gardeners grow it for its colourful, tightly packed flowerheads.

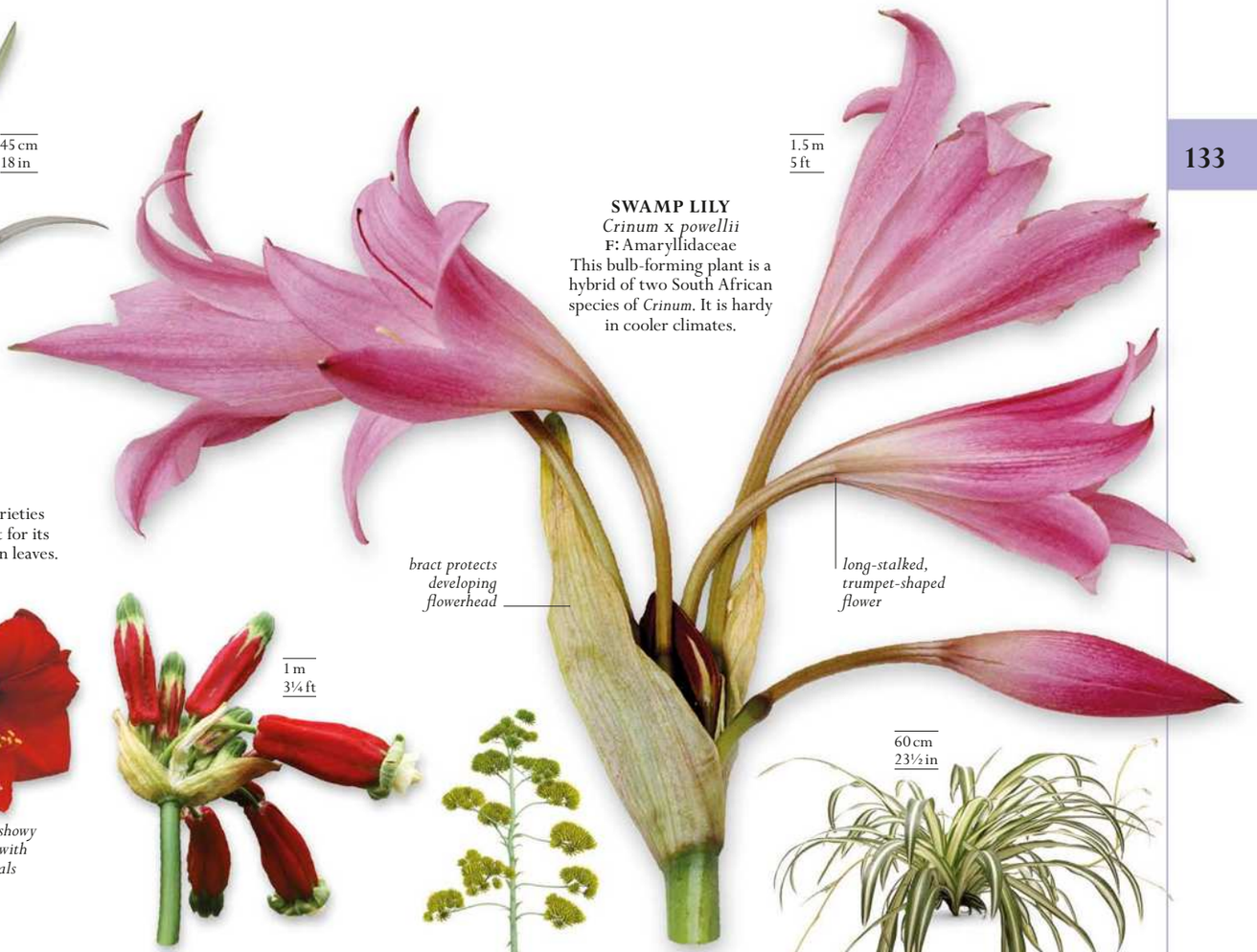
ONION
Allium cepa
F: Amaryllidaceae
Evidence from ancient Egypt shows that the onion has been cultivated for at least 5,000 years.

RAMSONS
Allium ursinum
F: Amaryllidaceae
Related to and smelling of garlic, this plant often carpets the floors of European woodlands in spring with its broad green leaves.

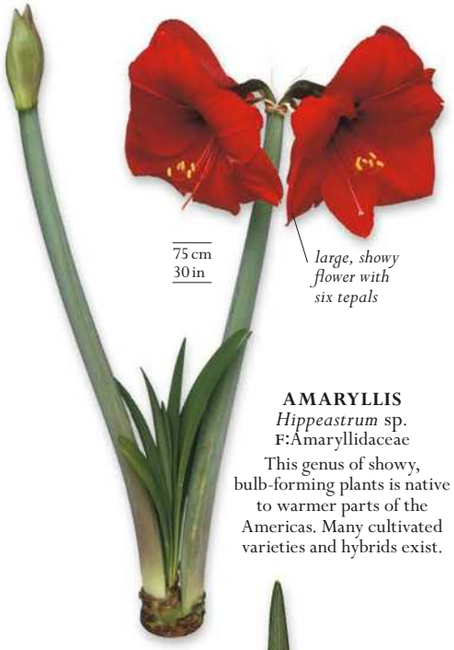
AFRICAN LILY
Agapanthus africanus
F: Amaryllidaceae
Native to South Africa, this plant has a tall, flowering stem and narrow, arching leaves. It can survive fires in its native habitat, regrowing from a fleshy underground stem.

SNOWDROP
Galanthus nivalis
F: Amaryllidaceae
The early spring flowers of this shade-tolerant European native have three white sepals that are much longer than the three inner petals.

NATAL LILY
Clivia miniata
F: Amaryllidaceae
Horticulturalists have bred many varieties of this South African woodland plant for its showy flowers and strap-like evergreen leaves.

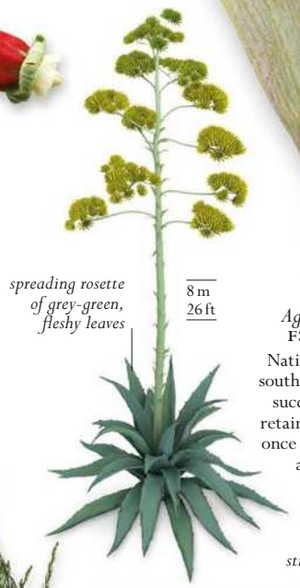


SWAMP LILY
Crinum x *powellii*
F: Amaryllidaceae
This bulb-forming plant is a hybrid of two South African species of *Crinum*. It is hardy in cooler climates.



AMARYLLIS
Hippeastrum sp.
F: Amaryllidaceae
This genus of showy, bulb-forming plants is native to warmer parts of the Americas. Many cultivated varieties and hybrids exist.

FIRECRACKER FLOWER
Dichelostemma ida-maia
F: Asparagaceae
Native to Oregon and northern California, this mainly woodland species has attractive tubular flowers that make it popular as a garden plant.



CENTURY PLANT
Agave americana
F: Asparagaceae
Native to Mexico and southwestern USA, this succulent, or water-retaining plant, flowers once after 10–30 years and then dies.

SPIDER PLANT
Chlorophytum comosum
F: Asparagaceae
Forming new plantlets from its leaves and arching stems, the variegated forms of this African species are well known as houseplants.

WILD DAFFODIL
Narcissus pseudonarcissus
F: Amaryllidaceae
The ancestor of many cultivated varieties of daffodil, this native European species of mountains and woods is becoming rarer.

ST BERNARD'S LILY
Anthericum liliago
F: Asparagaceae
This European native with grass-like leaves likes sunny hillsides and other open places. It prefers rich, moist soils.

COMMON ASPARAGUS
Asparagus officinalis
F: Asparagaceae
Cultivated for its tender young shoots (spears), this European species becomes a tall, feathery plant if left to grow.

SPANISH DAGGER
Yucca gloriosa
F: Asparagaceae
Like all yuccas, this coastal species from S.E. USA relies on a specialized yucca moth for pollination.

JOSHUA TREE
Yucca brevifolia
F: Asparagaceae
Native to the USA's Mojave Desert, this woody, many-branched yucca is thought to live for hundreds of years.

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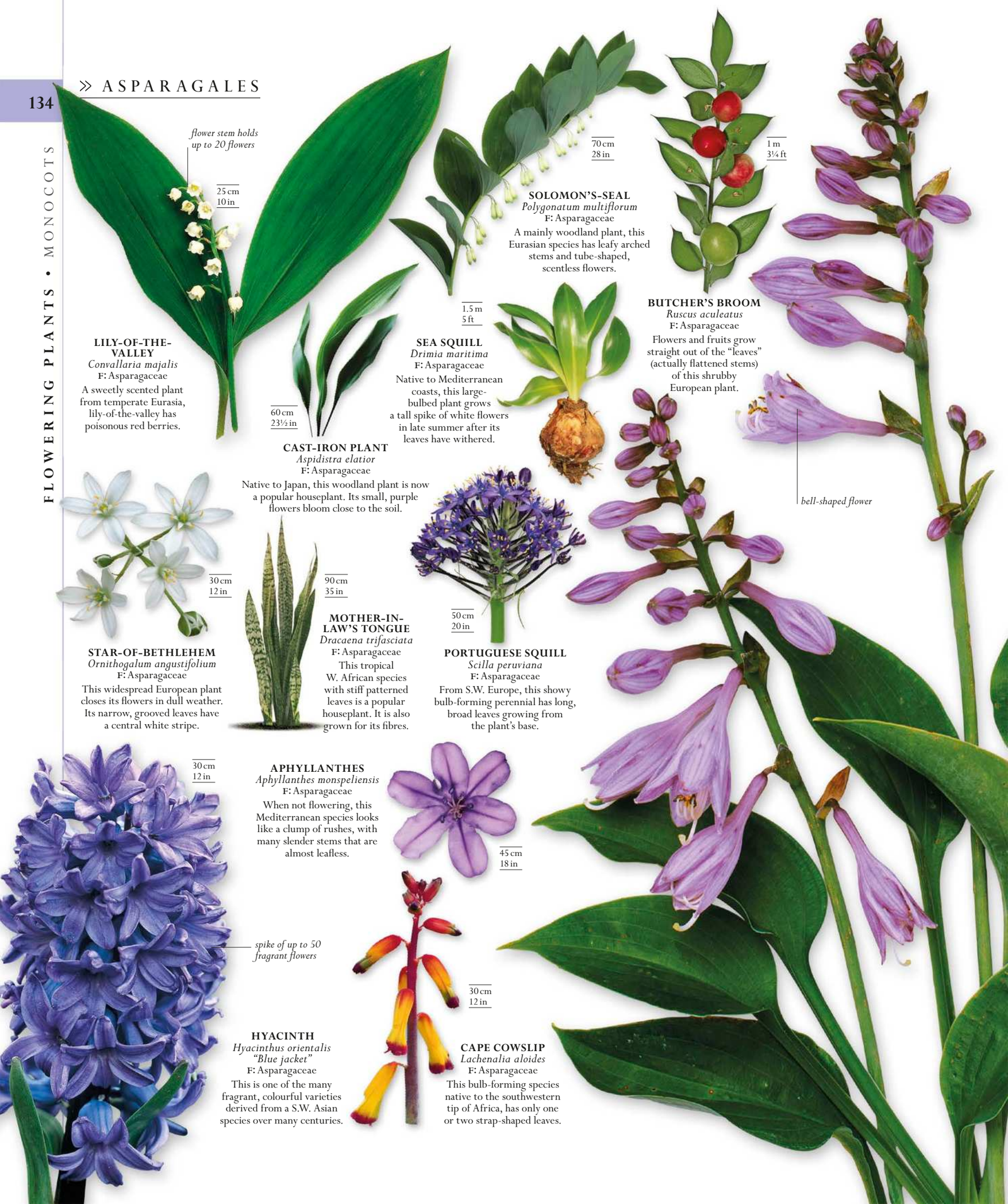


LILY-OF-THE-VALLEY
Convallaria majalis
F: Asparagaceae
A sweetly scented plant from temperate Eurasia, lily-of-the-valley has poisonous red berries.

SOLOMON'S-SEAL
Polygonatum multiflorum
F: Asparagaceae
A mainly woodland plant, this Eurasian species has leafy arched stems and tube-shaped, scentless flowers.

BUTCHER'S BROOM
Ruscus aculeatus
F: Asparagaceae
Flowers and fruits grow straight out of the "leaves" (actually flattened stems) of this shrubby European plant.

SEA SQUILL
Drimia maritima
F: Asparagaceae
Native to Mediterranean coasts, this large-bulbed plant grows a tall spike of white flowers in late summer after its leaves have withered.

CAST-IRON PLANT
Aspidistra elatior
F: Asparagaceae
Native to Japan, this woodland plant is now a popular houseplant. Its small, purple flowers bloom close to the soil.

STAR-OF-BETHLEHEM
Ornithogalum angustifolium
F: Asparagaceae
This widespread European plant closes its flowers in dull weather. Its narrow, grooved leaves have a central white stripe.

MOTHER-IN-LAW'S TONGUE
Dracaena trifasciata
F: Asparagaceae
This tropical W. African species with stiff patterned leaves is a popular houseplant. It is also grown for its fibres.

PORTUGUESE SQUILL
Scilla peruviana
F: Asparagaceae
From S.W. Europe, this showy bulb-forming perennial has long, broad leaves growing from the plant's base.

APHYLLANTHES
Aphyllanthes monspeliensis
F: Asparagaceae
When not flowering, this Mediterranean species looks like a clump of rushes, with many slender stems that are almost leafless.

HYACINTH
Hyacinthus orientalis "Blue jacket"
F: Asparagaceae
This is one of the many fragrant, colourful varieties derived from a S.W. Asian species over many centuries.

CAPE COWSLIP
Lachenalia aloides
F: Asparagaceae
This bulb-forming species native to the southwestern tip of Africa, has only one or two strap-shaped leaves.

BLUE PLANTAIN LILY
Hosta "Halycon"
F: Asparagaceae
This hybrid is one of many garden varieties of *Hosta*, a genus of shade-tolerant plants native to N.E. Asia.

45 cm
18 in

45 cm
18 in

ENGLISH BLUEBELL
Hyacinthoides non-scripta
F: Asparagaceae
Native to W. Europe, this bulb-forming plant sometimes carpets whole woodland floors with blue flowers in spring.

1 m
3¼ ft

GREAT CAMAS
Camassia leichtlinii
F: Asparagaceae
The edible bulbs of several *Camassia* species were cooked like potatoes by Native American peoples as a staple food called Quamash.

15 m
50 ft

DRAGON TREE
Dracaena draco
F: Asparagaceae
Rare in its native Canary Islands and Madeira, this many-branched tree survives as a popular ornamental. Its red sap was prized as "dragon's blood".

60 cm
23½ in

TASSEL HYACINTH
Muscari comosum
F: Asparagaceae
The flowerheads of this Mediterranean species have fertile and sterile flowers, the latter forming the purplish "tassel" at the top.

80 cm
32 in

COMMON FRINGE LILY
Thysanotus tuberosus
F: Asparagaceae
Native to S.E. Australia, this narrow-leaved plant has fringe-petalled flowers that each open for only one day.

1 m
3¼ ft

FIELD GLADIOLUS
Gladiolus italicus
F: Iridaceae
A Mediterranean member of the iris family, the field gladiolus flowers between March and June.

1 m
3¼ ft

BEARDED IRIS
Iris germanica
F: Iridaceae
Botanists are unsure whether this fragrant-flowered garden iris was once native to the E. Mediterranean or originated as a garden hybrid.

60 cm
23½ in

MONTBRETIA
Crocosmia x *crocosmiiflora*
F: Iridaceae
A 19th-century hybrid created from two South African species, this popular garden plant is invasive in some areas.

20 m
65 ft

CABBAGE TREE
Cordyline australis
F: Asparagaceae
One of New Zealand's most common trees, shown here as a young plant, the cabbage tree develops a sturdy trunk topped by dense tufts of narrow leaves and showy spikes of white flowers.

1 m
3¼ ft

PALE YELLOW-EYED GRASS
Sisyrinchium striatum
F: Iridaceae
Native to Chile and Argentina, this representative of a large New World genus has pale flowers marked with fine purple stripes.

30 cm
12 in

SAFFRON CROCUS
Crocus sativus
F: Iridaceae
The dried stigmas of this cultivated Mediterranean crocus have long been sold as saffron, used for colouring and flavouring food.

KEW'S FREESIA
Freesia x *kewensis*
F: Iridaceae
Derived from native South African ancestors, this freesia is a sweet-smelling garden hybrid in the northern hemisphere.

60 cm
23½ in

60 cm
23½ in

GRAND CHRISTMAS BELLS
Blandfordia grandiflora
F: Blandfordiaceae
Nectar-sipping birds seek out this large-flowered species of coastal E. Australia. Its leaves are narrow and grass-like.

45 cm
18 in

BARBARY NUT
Gynandriris sisyrinchium
F: Iridaceae
This wild Mediterranean iris grows from a corm (a bulb-like underground stem), which helps it survive unfavourable conditions.

»

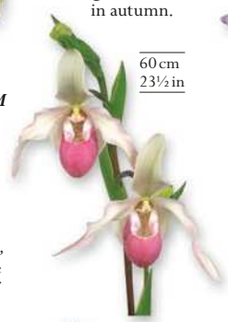
FAIRY SLIPPER ORCHID
Calypso bulbosa
F: Orchidaceae
Widespread across cooler parts of the northern hemisphere, this fragrant single-flowered orchid prefers damp woodland and marshland.

***ONCIDIUM* SP.**
F: Orchidaceae
Native to the tropical Americas, this genus of broad-lipped orchids includes around 330 tree-living species of varying sizes.

LESSER BUTTERFLY ORCHID
Platanthera bifolia
F: Orchidaceae
Found in various habitats across temperate Eurasia, this sweetly scented, pale-flowered orchid is visited and pollinated by night-flying moths.

PHRAGMIPEDIUM* X *SEDENII
F: Orchidaceae
This fragrant ground-living orchid is a hybrid created from species of the genus *Phragmipedium*, slipper orchids native to tropical regions of the Americas.

TRACY'S CYMBIDIUM
Cymbidium tracyanum
F: Orchidaceae
This epiphytic orchid from Burma, Thailand, and S.W. China produces its strongly fragrant flowers in autumn.



HYACINTH ORCHID
Dipodium squamatum
F: Orchidaceae
A leafless, ground-living Australian orchid, this species depends on associating with underground fungi to survive. It lives in woodland habitats.

PYRAMIDAL ORCHID
Anacamptis pyramidalis
F: Orchidaceae
This chalk-loving orchid from temperate Eurasia sticks its pollen sacs on to visiting butterflies and moths, as first described by Charles Darwin.

PINK LADY'S SLIPPER
Cypripedium acaule
F: Orchidaceae
Widespread in eastern N. America, this two-leaved slipper orchid favours acol soil as in pine forests.

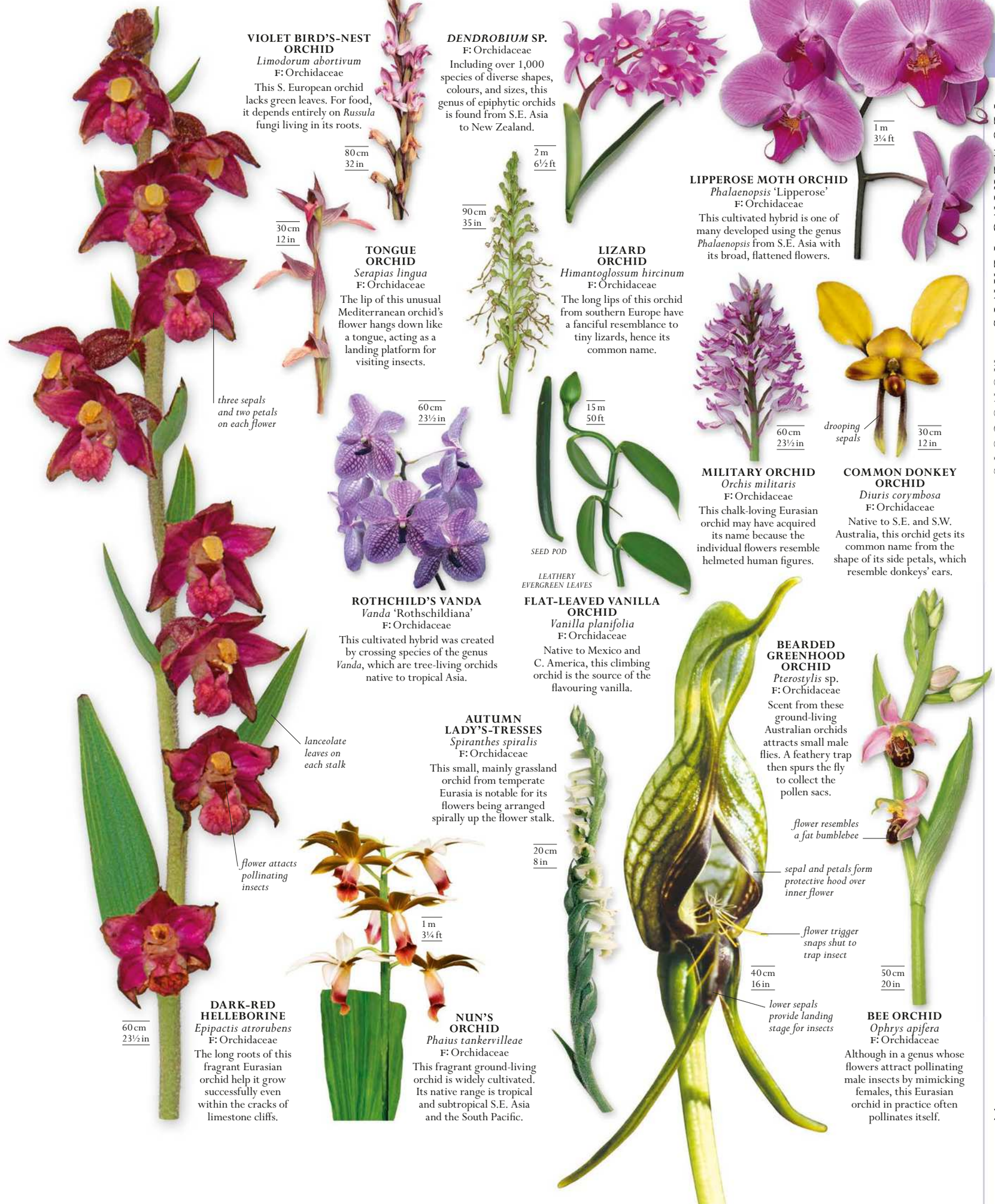
HAIRY SLIPPER ORCHID
Paphiopedilum villosum
F: Orchidaceae
Native to S. China and parts of S.E. Asia, this slipper orchid has been used to create many ornamental hybrids.

ORANGE GUARIANTHE
Guarianthe aurantiaca
F: *Orchidaceae*
This tree-living species is native to tropical C. America. Many ornamental varieties and hybrids have been bred by horticulturalists.

WAGENER'S MASDEVALLIA
Masdevallia wageneriana
F: Orchidaceae
The sepals of this small epiphytic orchid from the mountains of N. Venezuela have narrow "tails" (spurs), a feature typical of the genus.

WINDOWSILL ORCHID
Pleione formosana
F: Orchidaceae
Native to parts of China, this small ground-living orchid dies back during the winter months.

RED HELLEBORINE
Cephalanthera rubra
F: Orchidaceae
This ground-living species with rose-pink or purplish flowers grows in open woodlands from Europe eastwards to W. Asia.


three sepals and two petals on each flower
lanceolate leaves on each stalk
flower attacts pollinating insects
60 cm 23½ in
30 cm 12 in
80 cm 32 in
90 cm 35 in
2 m 6½ ft
60 cm 23½ in
15 m 50 ft
SEED POD
LEATHERY EVERGREEN LEAVES
1 m 3¼ ft
20 cm 8 in
1 m 3¼ ft
60 cm 23½ in
drooping sepals
30 cm 12 in
flower resembles a fat bumblebee
sepal and petals form protective hood over inner flower
flower trigger snaps shut to trap insect
40 cm 16 in
50 cm 20 in
lower sepals provide landing stage for insects

VIOLET BIRD'S-NEST ORCHID
Limodorum abortivum
F: Orchidaceae
This S. European orchid lacks green leaves. For food, it depends entirely on *Russula* fungi living in its roots.

***DENDROBIUM* SP.**
F: Orchidaceae
Including over 1,000 species of diverse shapes, colours, and sizes, this genus of epiphytic orchids is found from S.E. Asia to New Zealand.

LIPPEROSE MOTH ORCHID
Phalaenopsis 'Lipperose'
F: Orchidaceae
This cultivated hybrid is one of many developed using the genus *Phalaenopsis* from S.E. Asia with its broad, flattened flowers.

TONGUE ORCHID
Serapias lingua
F: Orchidaceae
The lip of this unusual Mediterranean orchid's flower hangs down like a tongue, acting as a landing platform for visiting insects.

LIZARD ORCHID
Himantoglossum hircinum
F: Orchidaceae
The long lips of this orchid from southern Europe have a fanciful resemblance to tiny lizards, hence its common name.

MILITARY ORCHID
Orchis militaris
F: Orchidaceae
This chalk-loving Eurasian orchid may have acquired its name because the individual flowers resemble helmeted human figures.

COMMON DONKEY ORCHID
Diuris corymbosa
F: Orchidaceae
Native to S.E. and S.W. Australia, this orchid gets its common name from the shape of its side petals, which resemble donkeys' ears.

ROTHCHILD'S VANDA
Vanda 'Rothschildiana'
F: Orchidaceae
This cultivated hybrid was created by crossing species of the genus *Vanda*, which are tree-living orchids native to tropical Asia.

FLAT-LEAVED VANILLA ORCHID
Vanilla planifolia
F: Orchidaceae
Native to Mexico and C. America, this climbing orchid is the source of the flavouring vanilla.

AUTUMN LADY'S-TRESSES
Spiranthes spiralis
F: Orchidaceae
This small, mainly grassland orchid from temperate Eurasia is notable for its flowers being arranged spirally up the flower stalk.

BEARDED GREENHOOD ORCHID
Pterostylis sp.
F: Orchidaceae
Scent from these ground-living Australian orchids attracts small male flies. A feathery trap then spurs the fly to collect the pollen sacs.

DARK-RED HELLEBORINE
Epipactis atrorubens
F: Orchidaceae
The long roots of this fragrant Eurasian orchid help it grow successfully even within the cracks of limestone cliffs.

NUN'S ORCHID
Phaius tankervilleae
F: Orchidaceae
This fragrant ground-living orchid is widely cultivated. Its native range is tropical and subtropical S.E. Asia and the South Pacific.

BEE ORCHID
Ophrys apifera
F: Orchidaceae
Although in a genus whose flowers attract pollinating male insects by mimicking females, this Eurasian orchid in practice often pollinates itself.

»

v RAMBLING STEMS
The many-bulbed orchid grows all over its chosen support structure, whether it be a rock or another plant, and forms a dense mat of stolons – the horizontal stems that reach out from the base of the plant.

broad, whitish petal forms a lip, which acts as a flag to attract pollinating insects
outer three sepals enclose the flower bud

MANY-BULBED ORCHID

Dinema polybulbon

This diminutive orchid is the only species in the genus *Dinema*. Rambling and prolific, it is an epiphytic or lithophytic plant, meaning that it grows on trees or rocks, using them for support. It gains its nutrients from the air, animal detritus, or other plant remains, and absorbs water from rain or mist. Moisture collects on the orchid's leaves, which are thick and waxy, and have reduced stomata – all features which help to reduce water loss. The leaves funnel water into upright, swollen outgrowths from the stems, called pseudobulbs. These act as water-storage organs to keep the orchid hydrated during tropical dry seasons. The creeping stems, with the pseudobulbs, in turn connect to aerial and (sometimes) underground roots. These absorb dissolved nutrients through a spongy, outer layer of cells called velamen. In winter, each pseudobulb produces a single flower. Plants can survive temperatures down to 7°C (45°F), and are a favourite of orchid collectors.

SIZE Height 7.5 cm (3 in)
HABITAT Humid, mixed forests
DISTRIBUTION Mexico, C. America, Jamaica, Cuba
LEAF TYPE Parallel veins

flattened leaf tip has a notch

PSEUDOBULB >
These small, oval, bulb-like outgrowths from the creeping stems store water for dry periods. Each produces one to three glossy leaves.

^ FLOWER
The pseudobulb produces a small, sweet-smelling flower with narrow, yellow-brown sepals, purple petals, and a spreading, white lip.

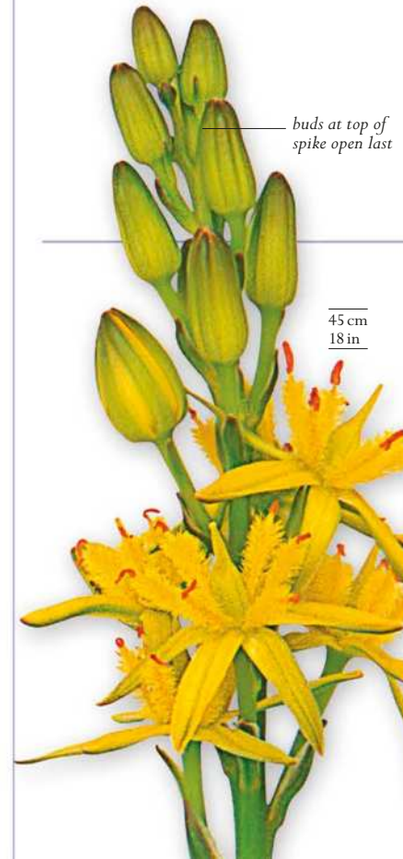
< POLLEN SACS (POLLINIA)
Orchid pollen grains are contained in two sacs. A sticky mass glues the sacs onto pollinating insects, which carry the pollen to another plant.

< AERIAL ROOTS
The orchid's aerial roots need not connect to the soil. The older parts of the root have a protective layer of dead cells that act like blotting paper to absorb and retain water.

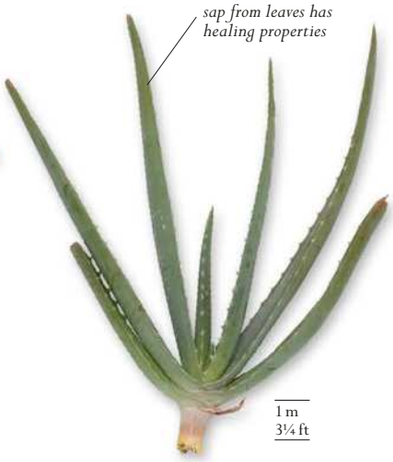
» ASPARAGALES

GRASS TREE
Xanthorrhoea australis
F: Asphodelaceae
Perhaps living for up to 450 years, this bushfire-resistant Australian plant develops a sturdy trunk and a spherical crown of narrow leaves.

COMMON ASPHODEL
Asphodelus aestivus
F: Asphodelaceae
This common narrow-leaved Mediterranean plant produces many pinkish white flowers on a tall stem.



NEW ZEALAND FLAX
Phormium tenax
F: Asphodelaceae
This common New Zealand species grows large leaves at ground level and a tall flower stalk bearing tubular reddish flowers.



MEDICINAL ALOE
Aloe vera
F: Asphodelaceae
This spiny succulent adapted to dry areas has been cultivated since ancient times for its reputed medicinal properties.

ORANGE DAY LILY
Hemerocallis fulva
F: Asphodelaceae
Each flower of this ornamental species lasts just one day. Native to Asia, it can be an invasive weed in N. America.

RED HOT POKER
Kniphofia uvaria
F: Asphodelaceae
Native to the S.W. tip of Africa, this multi-flowered lily with long, narrow leaves is now a popular ornamental specimen.

LILIALES

Many plants once considered part of the lily family, including onions and hyacinths, have been moved into the order Asparagales (see pp.132–39). The ten families in the Liliales include the true lilies and tulips, the sarsaparilla and colchicum families, and the colourful alstroemeria family from the New World. Beware that several lily species are highly toxic to cats.

WILD TULIP
Tulipa sylvestris
F: Liliaceae
Still widespread as a native plant in southern Europe, this yellow-flowered relative of the cultivated garden tulip grows wild in meadows, open woodland, and rocky places.

HERB PARIS
Paris quadrifolia
F: Liliaceae
Found in ancient woodland in temperate Eurasia, this four-leaved plant has a single green flower that develops into a black inedible fruit.

SNAKESHEAD FRITILLARY
Fritillaria meleagris
F: Liliaceae
This bulb-forming European species has distinctive chequered flowers. It grows wild in damp meadows but is more common in cultivation.

DIOSCOREALES

This order contains just three families. It is dominated by the yams, a family of mainly tropical climbing plants. Several species of yam have been cultivated since ancient times for their edible tubers. The small bog asphodel family is mainly north temperate.

BOG ASPHODEL
Narthecium ossifragum
F: Nartheciaceae
This European plant lives in nutrient-poor upland habitats. After fertilization, its seed capsules develop a fiery orange colour.

YAM
Dioscorea sp
F: Dioscoreaceae
Widely cultivated in the tropics, yams grow large, starch-rich tubers. Plants have stems that trail or climb and heart-shaped leaves.

BLACK BRYONY
Tamus communis
F: Dioscoreaceae
This poisonous European climbing plant of the yam family is named for its black underground tuber. Its globular fruits turn bright red when ripe.

MADONNA LILY
Lilium candidum
F: Liliaceae
Often encountered in Christian art as a symbol of purity, this widely cultivated lily is native to the E. Mediterranean.

2 m
6½ ft

female stigma receives the pollen

male stamen releases the pollen

15 cm
6 in

GAGEA RETICULATA
F: Liliaceae
This small bulb-forming plant grows in open habitats across much of temperate Asia, as well as S.E. Europe and N. Africa.

2 m
6½ ft

TURK'S CAP LILY
Lilium martagon
F: Liliaceae
This widespread Eurasian lily has the reflexed (backwards-bending) tepals that form the flower shape characteristic of the species.

2 m/6½ ft

FLAME LILY
Gloriosa superba
F: Colchicaceae
This striking plant, found from S. Africa to S.E. Asia, is a climber, clambering upwards with the aid of tendrils.

FLOWERHEADS

15 cm
6 in

MEADOW SAFFRON
Colchicum autumnale
F: Colchicaceae
The crocus-like flowers of this European native appear in the autumn, months before its leaves. Despite being poisonous, it is cultivated widely.

TYPICAL LEAF

3 m
10 ft

GIANT HIMALAYAN LILY
Cardiocrinum giganteum
F: Liliaceae
Found from the Himalayas to China, this giant lily grows for several seasons before flowering, after which the main plant dies.

flower with six tepals (lobes)

leaf twists from stem so underside faces upwards

leaves arranged spirally up stem

up to 40 tubular flowers

TRAILING LILY
Bomarea multiflora
F: Alstroemeriaceae
This many-stemmed climbing plant, with clusters of orange-red flowers, is native to S. America.

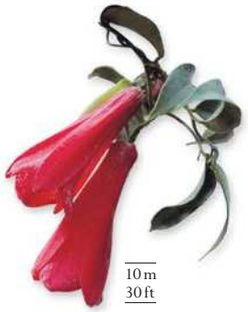
4 m
13 ft

PERUVIAN LILY
Alstroemeria sp.
F: Alstroemeriaceae
This lily-like S. American genus includes many popular ornamentals. The leaves twist during growth to become anatomically upside down.

1.2 m
4 ft

»

» LILIALES



CHILEAN BELLFLOWER
Lapageria rosea
F: Philesiaceae
Cultivated for its spectacular bell-shaped flowers, this twining climber is native to humid woodlands of Chile.

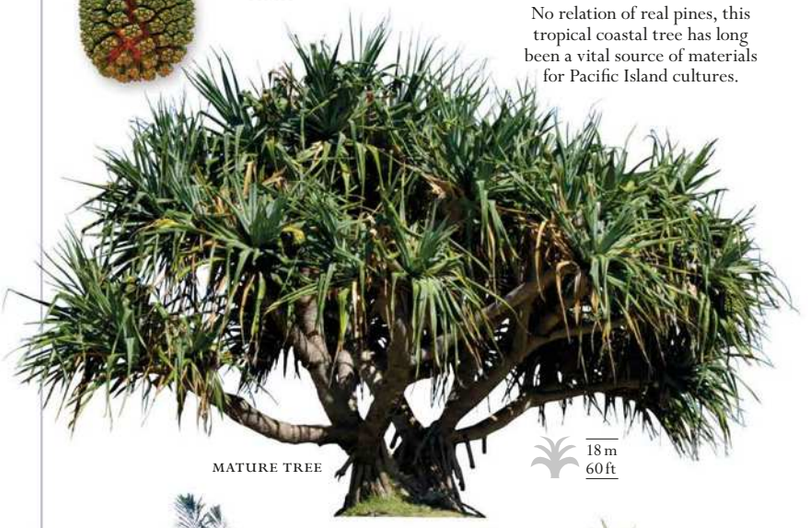
FALSE HELLEBORINE
Veratrum sp.
F: Melanthiaceae
Native to the northern hemisphere, this genus of poisonous plants produces branched flowerheads of greenish white flowers.

SMILAX
Smilax aspera
F: Smilacaceae
Native to the Mediterranean and S.W. Asia, this vigorous climber bears male and female flowers on separate plants.

PANDANALES

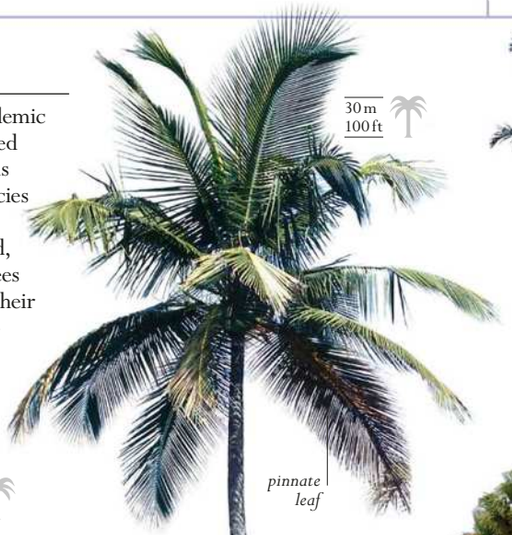
Found mainly in the tropics, the five families in this order include over 1,300 species of trees, shrubs, climbers, and smaller plants. Many look superficially like palms, except that they have simpler, strap-shaped leaves. Around half of them belong to the single genus *Pandanus* (screw pines).

THATCH SCREW PINE
Pandanus tectorius
F: Pandanaceae
No relation of real pines, this tropical coastal tree has long been a vital source of materials for Pacific Island cultures.



ARECALES

Since 2016, a family of 16 endemic Australian trees has been added to the order Arecales, which is dominated by over 2,000 species in the palm family. Typically growing from one central bud, palms vary from towering trees to slender climbing rattans. Their huge leaves are either feather-shaped or fan-like. Often associated with desert islands, most species actually live in tropical rainforests.



COCONUT PALM
Cocos nucifera
F: Arecaceae
Now widely cultivated, this species probably originated in the W. Pacific, colonizing new islands via its floating fruits.

BETEL NUT PALM
Areca catechu
F: Arecaceae
Cultivated for its seeds, which release a psychoactive substance when chewed, this palm originates from S.E. Asia.

SUGAR PALM
Arenga pinnata
F: Arecaceae
This native of India and S.E. Asia grows showy yellow flowerheads. It yields many products including sugar from its sap and fibres.

DATE PALM
Phoenix dactylifera
F: Arecaceae
Seen here as a young tree, this cultivated palm from the Middle East grows as separate male and female trees.

DESERT FAN PALM
Washingtonia filifera
F: Arecaceae
Dead leaves hanging below this palm's crown provide shelter for birds and insects in its native deserts of S.W. USA.

PETTICOAT PALM
Copernicia macroglossa
F: Arecaceae
Native to Cuba, this relatively small palm is named for the skirt of dead leaves that it retains below its crown.

AFRICAN OIL PALM
Elaeis guineensis
F: Arecaceae

A plant of humid tropical lowlands, this palm is extensively cultivated beyond its native Africa for the oils contained in its fruits.

BOTTLE PALM
Hyophorbe lagenicaulis
F: Arecaceae

This swollen-based palm comes from tiny Round Island near Mauritius. It is widely grown as an ornamental.

SAGO PALM
Metroxylon sagu
F: Arecaceae

Shown here as a young plant, this swamp-living palm probably originated in New Guinea but is now grown throughout S.E. Asia.

CHUSAN PALM
Trachycarpus fortunei
F: Arecaceae

From C. China, this cold-tolerant species has separate male and female plants. The females produce round, blue-black fruits.

COCO DE MER
Lodoicea maldivica
F: Arecaceae

The seeds of this palm from the Seychelles are the biggest in the plant kingdom. They take six years to mature.

ROYAL PALM
Roystonea regia
F: Arecaceae

Often planted in stately avenues in the tropics, this handsome smooth-trunked species is native from C. America to Florida and Cuba.

RAFFIA PALM
Raphia farinifera
F: Arecaceae

At 20 m (65 ft) long, the leaves of this African palm are the largest of any tree.

PALMYRA PALM
Borassus flabellifer
F: Arecaceae

This tall-trunked species from S. Asia favours drier habitats. It is cultivated for its fruits and sugar-yielding sap.

BRAZILIAN WAX PALM
Copernicia prunifera
F: Arecaceae

A waxy coating on the leaves of this palm from N.E. Brazil helps it resist drought. The harvested wax is used in polish and soap.

EUROPEAN FAN PALM
Chamaerops humilis
F: Arecaceae

Often trunkless in the wild, cultivated specimens grow several short trunks from a single base. It originates from Mediterranean countries.

CHILEAN WINE PALM
Jubaea chilensis
F: Arecaceae

Also known as the coquito palm, this massive-trunked, cold-tolerant palm is native only to C. Chile, where it is now a protected species.

COMMELINALES

This order contains five families, two of which are minor groups of around five species each, plus the three larger families illustrated here. Most are low-growing plants, typically from warmer regions. Many have attractive three-petalled blue flowers (reduced to two petals in some species), making them popular as ornamentals.

BLUE SPIDERWORT
Commelina coelestis
F: Commelinaceae
Sometimes planted as ground cover, this sprawling plant is native to Mexico and C. America.

QUEEN'S SPIDERWORT
Dichorisandra reginae
F: Commelinaceae
A popular garden flower grown in warmer regions, this tropical woodland species is from Peru. It has blue flowers with white centres.

TURTLE VINE
Callisia repens
F: Commelinaceae
This succulent plant from forest edges in the American tropics spreads by rooting from creeping stems.

TAHITIAN BRIDAL VEIL
Callisia procumbens
F: Commelinaceae
Native to C. and S. America, this species has weak stems and three-petalled, white flowers.

SILVER INCH PLANT
Tradescantia zebrina
F: Commelinaceae
With striped, succulent foliage, this ground-living species from the tropical Americas is also a popular houseplant.

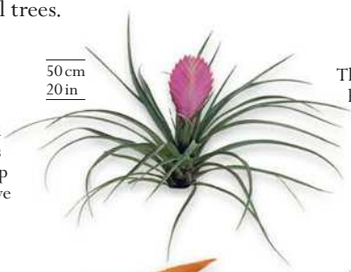
POALES

The 14 families in the Poales include wind-pollinated families that dominate certain ecosystems: grasses in prairies and savannas, sedges and rushes in bogs and heathlands, especially in the northern hemisphere, and restios in heathlands and swamps in the southern hemisphere. Bromeliads mainly live as epiphytes growing on tropical trees.

SCARLET STAR
Guzmania lingulata
F: Bromeliaceae
This tree-living bromeliad has a wide native range from C. America to Brazil. It is a popular ornamental species.

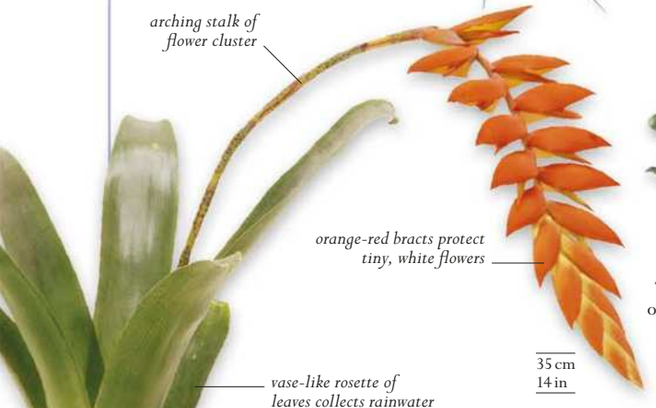
SLENDER CLUB-RUSH
Isolepis cernua
F: Cyperaceae
With narrow green stems and silvery flowerheads, this widespread temperate sedge is also dubbed "fibre-optics grass".

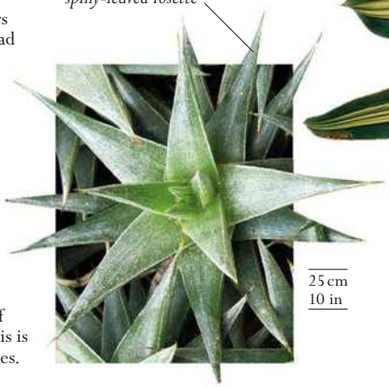
PINK QUILL
Wallisia cyanea
F: Bromeliaceae
Native to Ecuador and Peru, pink quill grows on rainforest trees at up to 850 m (2,800 ft) above sea level.



PINEAPPLE
Ananas comosus
F: Bromeliaceae
Christopher Columbus introduced Europeans to this cultivated bromeliad with its large, seedless fruits. Its wild origins are uncertain.

BIRD'S NEST BROMELIAD
Nidularium innocentii
F: Bromeliaceae
The small, white flowers of this Brazilian bromeliad nestle within the chamber formed by the surrounding coloured bracts.


arching stalk of flower cluster
orange-red bracts protect tiny, white flowers
35 cm
14 in
vase-like rosette of leaves collects rainwater



LORENTZ'S BROMELIAD
Deuterocohnia lorentziana
F: Bromeliaceae
Native to the Andes of Argentina and Bolivia, this is a ground-dwelling species.

DYER'S TILLANDSIA
Racinaea dyeriana
F: Bromeliaceae
This epiphytic bromeliad is endangered in the wild due to destruction of its native mangrove forests in Ecuador.

BLUSHING BROMELIAD
Neoregelia carolinae
F: Bromeliaceae
At flowering time, the central leaves of this Brazilian bromeliad turn crimson, and it produces blue or violet flowers.

flowers in compact conical cluster

3 m
10 ft

TALL KANGAROO PAW
Anigozanthos flavidus
F: Haemodoraceae
From sandy areas of S.W. Australia, this species gets its common name from the appearance of its woolly-haired flower buds.

yellow blotch on uppermost petal of each flower
45 cm
18 in
swollen leaf stalk

COMMON WATER HYACINTH
Pontederia crassipes
F: Pontederiaceae
Native to Amazonia, this floating plant is a major tropical pest, but can be used to absorb pollution.

1 m/3¼ ft

PICKEREL WEED
Pontederia cordata
F: Pontederiaceae
Fast-growing and with striking blue flowerheads, this water-edge species is common from eastern N. America south to Argentina.

spike of male flowers
1.4 m
4½ ft
spike of female flowers

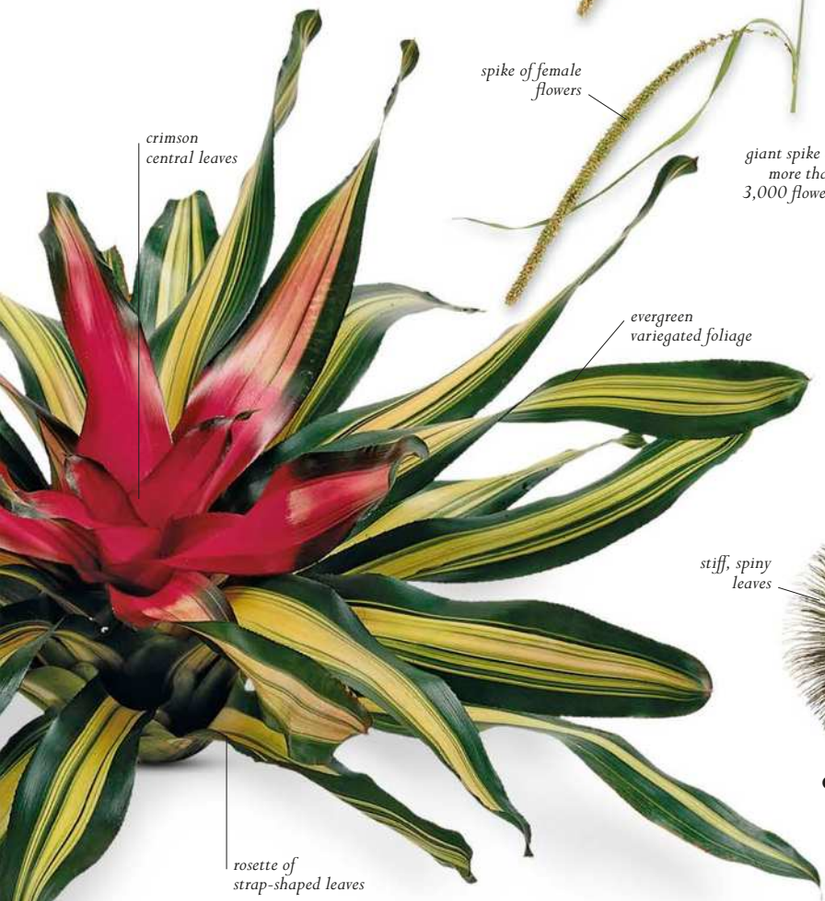
PENDULOUS SEDGE
Carex pendula
F: Cyperaceae
Like other true sedges (genus *Carex*), this European species has triangular stems and separate male and female flower clusters.

1.5 m
5 ft

CHINESE WATER CHESTNUT
Eleocharis dulcis
F: Cyperaceae
Native to Asia, this wetland sedge has clumps of tubular stems. It is cultivated for its edible underwater tubers.

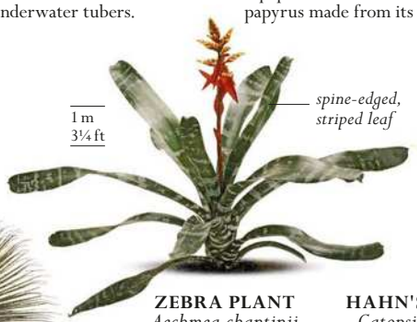
5 m/16 ft

PAPYRUS SEDGE
Cyperus papyrus
F: Cyperaceae
This tall African perrenial is a wetland plant. The Ancient Egyptians wrote on a paper-like material called papyrus made from its leaves.


crimson central leaves
evergreen variegated foliage
rosette of strap-shaped leaves

giant spike of more than 3,000 flowers
10 m
33 ft
stiff, spiny leaves

QUEEN OF THE ANDES
Puya raimondii
F: Bromeliaceae
Native to the C. Andes, the world's largest bromeliad produces a single colossal flower spike after many years' growth and then dies.


1 m
3¼ ft
spine-edged, striped leaf

ZEBRA PLANT
Aechmea chantinii
F: Bromeliaceae
This large, strap-leaved epiphytic bromeliad comes from the rainforests of S. America. It is pollinated by hummingbirds.

yellow bracts around small, white flowers
50 cm
20 in
grey-green leaves with waxy texture

HAHN'S CATOPSIS
Catopsis paniculata
F: Bromeliaceae
This epiphytic bromeliad is native to the cloud forests of S. Mexico and C. America.

» POALES

SOFT RUSH
Juncus effusus
F: Juncaceae
This very widespread rush thrives in damp infertile soils. Its cylindrical stems are filled with spongy tissue, or pith.

1.5 m
5 ft

1.3 m
4¼ ft

60 cm
23½ in

LARGE QUAKING GRASS
Briza maxima
F: Poaceae
This Mediterranean annual grass gets its name from the way its fine-stalked flowerheads shake at the slightest breeze.

1.8 m
6 ft

FALSE OAT-GRASS
Arrhenatherum elatius
F: Poaceae
Common across its native Europe, this tall-flowered wild relative of the oat has now spread to many other parts of the world.

60 cm
23½ in

SAND COUCH
Thinopyrum junceiforme
F: Poaceae
This tough grass grows on the seaward side of European sand dunes. Its roots, or rhizomes, help to hold the windblown sand together to form foredunes.

75 cm
30 in

CRESTED DOG'S-TAIL
Cynosurus cristatus
F: Poaceae
Low-growing apart from its flower stalks, this perennial grass from Europe and W. Asia resists trampling and is often used for lawns.

COCK'S-FOOT
Dactylis glomerata
F: Poaceae
Often grown in hayfields and pastures, this common grass with distinctive tufty flowerheads is native to Eurasia and N. Africa.

2.5 m
8¼ ft

young seeds

JOB'S TEARS
Coix lacryma-jobi
F: Poaceae
Native to C. Asia, this grass is grown around the tropics as a cereal or fodder crop. The hard seeds of wild plants are used as beads.

DRIED SEEDHEAD

60 cm
23½ in

6 m
20 ft

TALL, BROAD LEAF

HARE'S TAIL
Lagurus ovatus
F: Poaceae
The distinctive soft-haired flowerheads of this mainly coastal Mediterranean grass make it popular in dried flower arrangements.

GIANT REED
Arundo donax
F: Poaceae
Originally from C. Asia, this outsize marshland grass has been widely planted elsewhere. Its woody stems have many traditional uses.

EVERGREEN LEAVES

7 m
23 ft

BLACK BAMBOO
Phyllostachys nigra
F: Poaceae
Like all the bamboos, this black-stemmed species has hard, woody stems. It is native to E. and S. China. Bamboos are the fastest growing woody plant, growing up to 90 cm (35 in) a day.

FINGER-THICK CANE

awns protect seeds

THREE-AWNED GOAT GRASS
Aegilops neglecta
F: Poaceae
A relative of wheat,this low-growing, drought-resistant annual grass is native to the Mediterranean and Middle East.

35 cm
14 in

6 m
20 ft

COMMON REED
Phragmites australis
F: Poaceae

Widespread in both temperate and tropical regions, this shallow-water grass can colonize large areas via its creeping horizontal stems.

1 m
3¼ ft

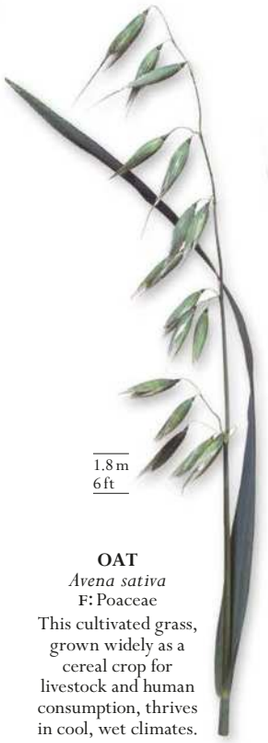
SWEET VERNAL GRASS
Anthoxanthum odoratum
F: Poaceae

Native to Eurasia, this early-flowering grass contains a chemical called coumarin that makes it smell pleasantly of new-mown hay.

1.2 m
4 ft

MARRAM GRASS
Calamagrostis arenaria
F: Poaceae

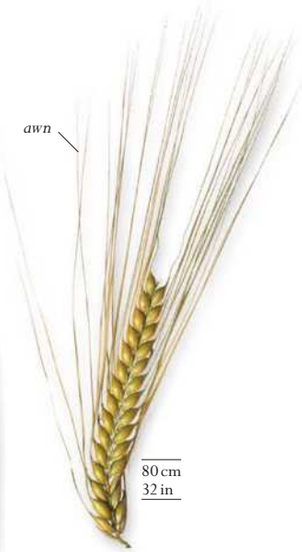
This tough grass from Europe flourishes on sand dunes, which its long underground stems and roots help to stabilize.



1.8 m
6 ft

OAT
Avena sativa
F: Poaceae

This cultivated grass, grown widely as a cereal crop for livestock and human consumption, thrives in cool, wet climates.



80 cm
32 in

BARLEY
Hordeum vulgare
F: Poaceae

Originating in the ancient Near East, this cultivated cereal grass is notable for the long hair-like bristles (awns) on its flowerheads.

1 m
3¼ ft

BREAD WHEAT
Triticum aestivum
F: Poaceae

The world's top-tonnage cereal, this species originated in the ancient Near East. It is a hybrid between the wild and earlier cultivated varieties.

40 cm
16 in

CREEPING BENT-GRASS
Agrostis stolonifera
F: Poaceae

This common perennial grass with feathery flowerheads is found worldwide. It spreads using creeping horizontal stems, or stolons.

3 m
10 ft

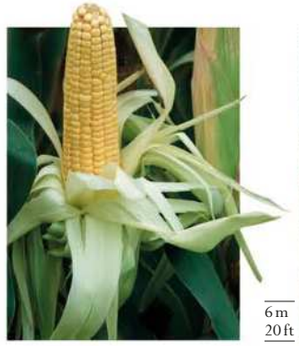
CITRONELLA
Cymbopogon nardus
F: Poaceae

A type of lemongrass, citronella originates from tropical Asia. It yields an oil used in perfumes and for repelling insects.

1.8 m
6 ft

RICE
Oryza sativa
F: Poaceae

Native to E. Asia, this major grain crop of warmer regions is usually cultivated in shallow water or in flood-prone areas.



3 m
10 ft

MAIZE
Zea mays
F: Poaceae

This major food crop was first cultivated in ancient Mexico. It has male or female flowerheads – edible corn is the female flower.

6 m
20 ft

SUGAR CANE
Saccharum officinarum
F: Poaceae

Possibly related to maize, this tropical cultivated grass may have originated in New Guinea. Sugar is extracted from its thick stems.

3 m
10 ft

VETIVER
Chrysopogon zizanioides
F: Poaceae

Native to India, this tropical grass is widely cultivated for its fragrant oil and to bind soils to prevent erosion.

90 cm
35 in

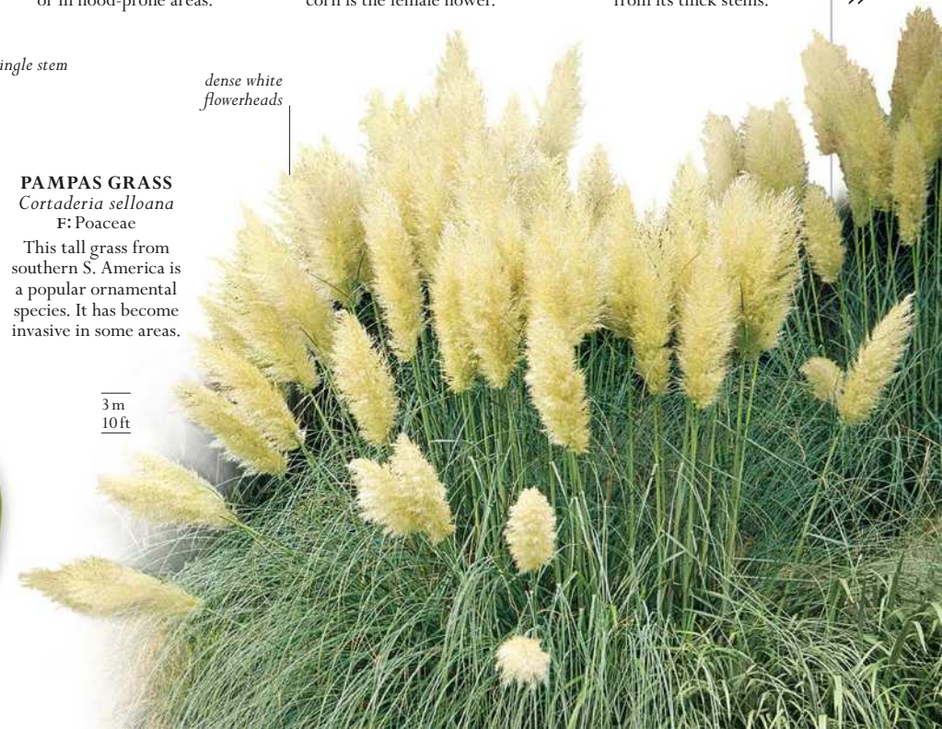
PERENNIAL RYE-GRASS
Lolium perenne
F: Poaceae

Much used in pastures, lawns, and sports fields, this common Eurasian grass has now spread around the world.

80 cm
32 in

YORKSHIRE FOG
Holcus lanatus
F: Poaceae

A common European grass found in damp meadows, Yorkshire fog has leaves with soft, velvety hairs.



3 m
10 ft

PAMPAS GRASS
Cortaderia selloana
F: Poaceae

This tall grass from southern S. America is a popular ornamental species. It has become invasive in some areas.

» POALES

GIANT FEATHER GRASS
Stipa gigantea
F: Poaceae
Gardeners cultivate this tall grass for its showy flowerheads, which persist until winter. It is native to Spain, Portugal and Morocco.

BRANCHED BUR-REED
Sparganium erectum
F: Typhaceae
Separate ball-shaped clusters of male and female flowers develop on the same flower stalk in this widespread wetland species of the northern hemisphere.

CATTAIL
Typha latifolia
F: Typhaceae
This widespread wetland plant has a distinctive cigar-shaped female flowerhead. The male flowers grow above it in a tuft.

YELLOW-EYED GRASS
Xyris sp.
F: Xyridaceae
This genus of grasslike plants, widespread in warmer regions of the world, bears small, yellow flowers on slender stems.

ZINGIBERALES

Many species in this mainly tropical order of eight families grow giant leaves at the end of stalks. Although there are no true woody trees, some species such as the banana plant grow very large. Many Zingiberales have showy flowers and foliage and have become ornamentals. The ginger family, Zingiberaceae, the largest in the order, includes several other important spice plants beside ginger itself.

INDIAN SHOT
Canna indica
F: Cannaceae
This tropical American plant has unusual flowers in which some of the petals are fused with pollen-producing stamens. There are many cultivated varieties.

NEVER-NEVER PLANT
Ctenanthe amabilis
F: Marantaceae
Native to forest floors in the Brazilian tropics, this warmth-loving plant requires high humidity if grown in cultivation.

ETERNAL FLAME
Goeppertia crocata
F: Marantaceae
Related to *Ctenanthe* and *Maranta*, this Brazilian species has more striking flowers than its relatives although living in similar forest habitats.

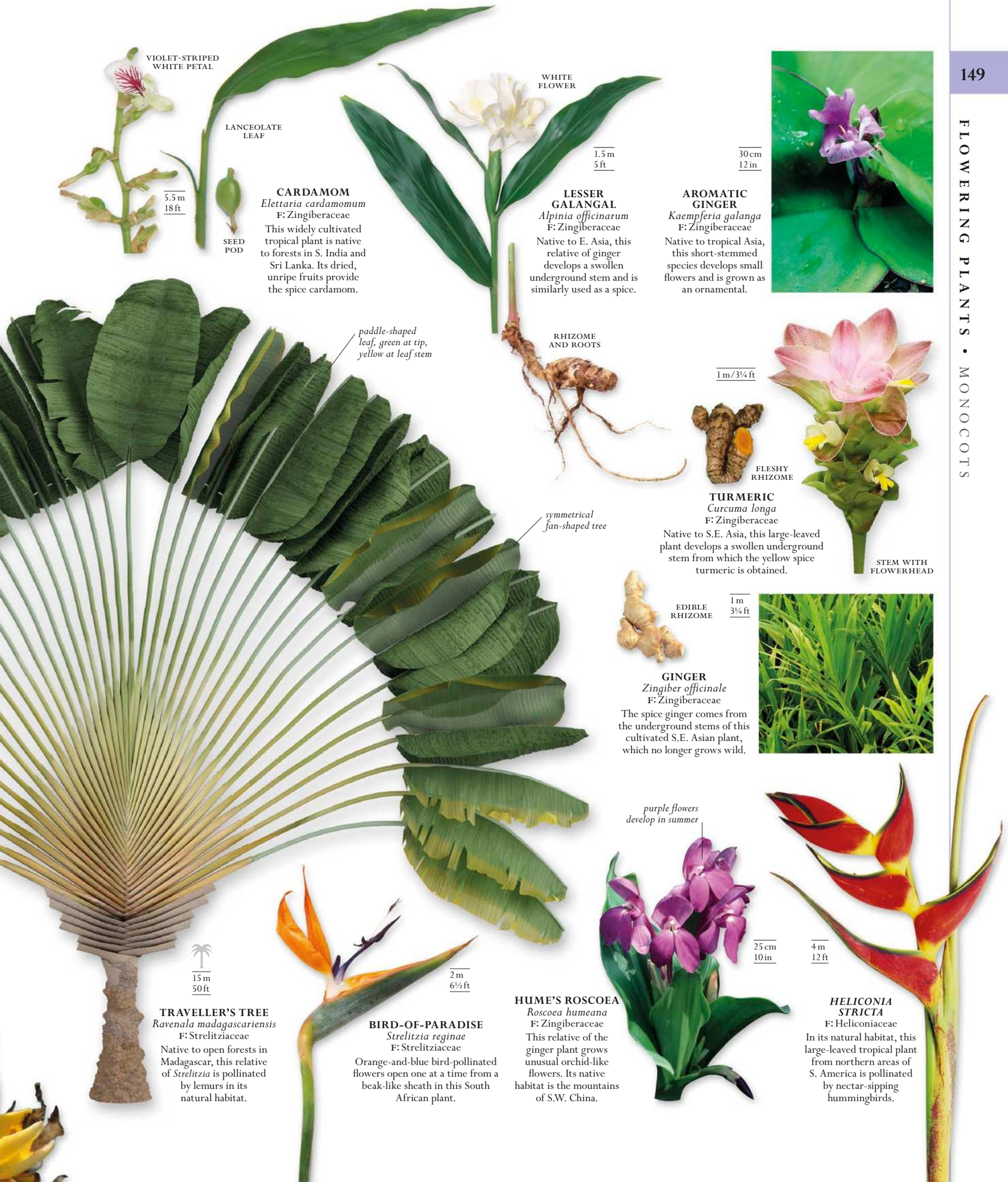
SPIRAL FLAG
Chamaecostus cuspidatus
F: Costaceae
This orange-flowered plant with dark green, glossy leaves is native to tropical E. Brazil. It is also grown as an ornamental.

SILVER-VEINED PRAYER PLANT
Maranta leuconeura
F: Marantaceae
This Brazilian forest plant folds its leaves together at night to conserve moisture. Cultivated varieties have strikingly patterned foliage.

ENSET
Ensete ventricosum
F: Musaceae
This African-relative of the banana has long been cultivated in Ethiopia for its nutritious rootstock and stem, not its (inedible) fruits.

BANANA
Musa acuminata
F: Musaceae
The seedless hybrid of Asian wild ancestors, cultivated bananas grow sterile male flowers at the end of their fruiting branches.

CHINESE YELLOW BANANA
Musella lasiocarpa
F: Musaceae
Possibly extinct in the wild, this mountain species from China produces a yellow flower spike that can last for months.



CARDAMOM
Elettaria cardamomum
F: Zingiberaceae
This widely cultivated tropical plant is native to forests in S. India and Sri Lanka. Its dried, unripe fruits provide the spice cardamom.

LESSER GALANGAL
Alpinia officinarum
F: Zingiberaceae
Native to E. Asia, this relative of ginger develops a swollen underground stem and is similarly used as a spice.

AROMATIC GINGER
Kaempferia galanga
F: Zingiberaceae
Native to tropical Asia, this short-stemmed species develops small flowers and is grown as an ornamental.

TURMERIC
Curcuma longa
F: Zingiberaceae
Native to S.E. Asia, this large-leaved plant develops a swollen underground stem from which the yellow spice turmeric is obtained.

GINGER
Zingiber officinale
F: Zingiberaceae
The spice ginger comes from the underground stems of this cultivated S.E. Asian plant, which no longer grows wild.

TRAVELLER'S TREE
Ravenala madagascariensis
F: Strelitziaceae
Native to open forests in Madagascar, this relative of *Strelitzia* is pollinated by lemurs in its natural habitat.

BIRD-OF-PARADISE
Strelitzia reginae
F: Strelitziaceae
Orange-and-blue bird-pollinated flowers open one at a time from a beak-like sheath in this South African plant.

HUME'S ROSCOEA
Roscoea humeana
F: Zingiberaceae
This relative of the ginger plant grows unusual orchid-like flowers. Its native habitat is the mountains of S.W. China.

HELICONIA STRICTA
F: Heliconiaceae
In its natural habitat, this large-leaved tropical plant from northern areas of S. America is pollinated by nectar-sipping hummingbirds.

EUDICOTS

Almost three-quarters of the world's known flowering plants are classified in the eudicot grouping, which evolved over 125 million years ago.

Eudicots get their name from the cotyledons, or seed-leaves, in the seed before it germinates. Unlike monocots, which have a single seed-leaf, eudicots have two. They include an enormous variety of plants, from agricultural weeds to towering rainforest trees, and they are of huge economic importance, as well as being prized as garden flowers. Many eudicots are annuals, with short lifespans measured in months or even weeks. Others are biennials and perennials, which live from two years to a century or more.

Despite their great diversity, eudicots have many physical features in common. Their leaves often have a net-like tracery of veins, unlike the parallel veins of monocots, and their stems have a well-developed vascular system, arranged in rings, for transporting water and sap. As well as getting taller, woody species thicken and strengthen their stems as they grow. This "secondary growth" is absent in most monocots, which is why eudicots make up most of the world's flowering shrubs and trees. Below ground level, most eudicots have a taproot, with smaller roots branching off it.

Eudicot flowers usually have parts in fours or fives, rather than the threes found in monocots, with sepals and petals that look different, both in colour and in shape. Each species has its own distinctive kind of pollen, but the grains always have three pores; monocot pollen grains only have a single opening.

A VITAL ROLE

The fossil pollen record suggests that the eudicots diverged from other flowering plants some 125 million years ago. Since then, they have colonized every habitat on land, although they are less common as waterplants. Their importance to animals is impossible to overestimate. Countless species – with the notable exception of grazing animals that feed on grasses (monocots) – depend on them for food and shelter, and in return, many act as pollinators, or help to spread their seeds.

DIVISION	ANGIOSPERMAE
CLADE	EUDICOTS
ORDERS	44
FAMILIES	312
SPECIES	Over 210,000

DEBATE

FOUR-WAY SPLIT

For many years, all flowering plants were classified in two groups – the monocotyledons (monocots) and the dicotyledons (dicots) – based on the number of their seed-leaves. However, DNA analysis, combined with palynology – the study of pollen – has shown this classification does not fully reflect plant evolution. As a result, flowering plants are now split into four overall groups: basal angiosperms, magnoliids, monocots, and the eudicots, or true dicots.

NEW PERSPECTIVES

Computer analysis of DNA data has suggested new ways of subdividing the eudicots. These new hierarchical groupings, known as clades (see pp.30–31), give insights into the relationships between species and how they evolved, but they are difficult to interpret in terms of physical characteristics of the resulting groups and do not fit neatly into the traditional taxonomic hierarchy. This book is organized around orders and families, which still provide the clearest way to understand the diversity of flowering plants. However, the table below shows how they "nest" together in the proposed new system of clades.

EUDICOTS (pp.150–209)
(BUXALES – DIPSACALES)

CORE EUDICOTS (pp.155–209)
(GUNNERALES – DIPSACALES)

SUPERROSIDS (pp.156–181)
(SAXIFRAGALES – SAPINDALES)

ROSIDS (pp.158–181)
(VITALES – SAPINDALES)

As its name suggests, Japanese rose belongs to the rosid group.

SUPERASTERIDS (pp.182–209)
(CARYOPHYLLALES – DIPSACALES)

ASTERIDS (pp.192–209)
(CORNALES – DIPSACALES)

Oxeye daisy is an asterid within the larger superasterid group.

BUXALES

Containing just a single family of around 120 species, the order Buxales is found in temperate, subtropical, and tropical regions. Most of the members are trees or shrubs, with simple, evergreen leaves and separate male and female flowers on the same plant. Many species are grown ornamentally and box wood is used for carving.

SWEET BOX
Sarcococca hookeriana
F: Buxaceae

This species bears clusters of small fragrant flowers in winter, and is found in shady habitats in W. China.

COMMON BOX
Buxus sempervirens
F: Buxaceae

Native to rocky woods and scrub from Europe to N. Africa, this evergreen shrub or small tree is often grown in gardens for topiary.

PROTEALES

Of the four Proteales families, the largest is the Proteaceae, evergreen trees and shrubs from the southern hemisphere. The Platanaceae are northern hemisphere deciduous trees, and the Nelumbonaceae are aquatic plants from Asia, Australia, and North America.

KING PROTEA
Protea cynaroides
F: Proteaceae

This species is native to hillsides and scrub in South Africa. Clusters of small flowers are enclosed by petal-like bracts.

SACRED LOTUS
Nelumbo nucifera
F: Nelumbonaceae

Growing in shallow freshwater habitats in parts of Asia and Australia, sacred lotus carries large fragrant flowers on long stalks above the water.

RED SILKY OAK
Grevillea banksii
F: Proteaceae

Cultivated as an ornamental species for its striking "bottle-brush" flowers, this native of N.E. Australia grows in woods and open habitats.

HONEYSUCKLE GREVILLEA
Grevillea juncifolia
F: Proteaceae

Found in drier inland regions across Australia, this erect shrub has narrow, grey-green leaves and tight heads of orange flowers with long, yellow styles.

WARATAH
Telopea speciosissima
F: Proteaceae

From dry woodland in New South Wales, Australia, common waratah is also known as Sydney waratah.

MOUNTAIN DEVIL
Lambertia formosa
F: Proteaceae

From coastal heathland to mountain forests in New South Wales, Australia, this species has red-tinged bracts surrounding the flower clusters.

PINCUSHION PROTEA
Leucospermum cordifolium
F: Proteaceae

This shrub of sandstone soils in South Africa's Cape Province is noted for its brightly coloured, spherical flowerheads.

SAW BANKSIA
Banksia serrata
F: Proteaceae

Saw Banksia grows in woodland and scrub in E. Australia. Its bark is fire-resistant, enabling it to survive bushfires.

NARROW-LEAF DRUMSTICKS
Isopogon anemonifolius
F: Proteaceae

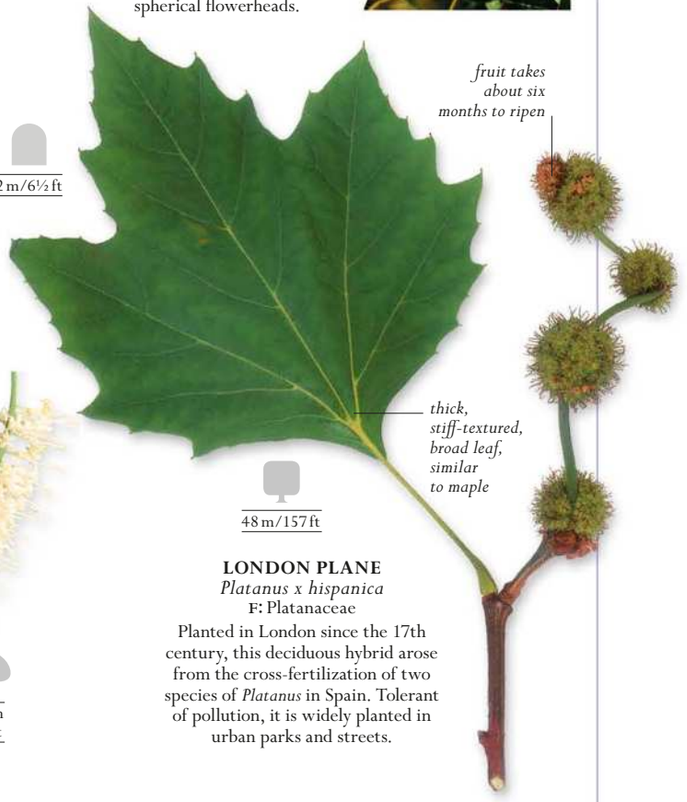
Spherical, yellow flowerheads above feathery leaves characterize this shrub, native to dry woodland and heathland in New South Wales, Australia.

CHILEAN FIRE BUSH
Embothrium coccineum
F: Proteaceae

From forest and open habitats in S. Chile and Argentina, this species is cultivated for its flame-coloured flowers, and thrives in sheltered gardens.

MACADAMIA NUT
Macadamia integrifolia
F: Proteaceae

Native to coastal rainforest in E. Australia, macadamias are cultivated for their edible nuts.



LONDON PLANE
Platanus x hispanica
F: Platanaceae

Planted in London since the 17th century, this deciduous hybrid arose from the cross-fertilization of two species of *Platanus* in Spain. Tolerant of pollution, it is widely planted in urban parks and streets.

RANUNCULALES

The order Ranunculales, consists of seven families. Four are relatively obscure, with few species, but the buttercup family, Ranunculaceae – after which the order is named – contains around 3,200 species. Together with members of the poppy and barberry families, these include some of the most common agricultural weeds worldwide and many familiar garden plants.

OREGON GRAPE
Berberis aquifolium
F: Berberidaceae

Flowering in springtime, Oregon grape is a suckering evergreen shrub from N.W. USA. It grows in shady habitats.

SACRED BAMBOO
Nandina domestica
F: Berberidaceae

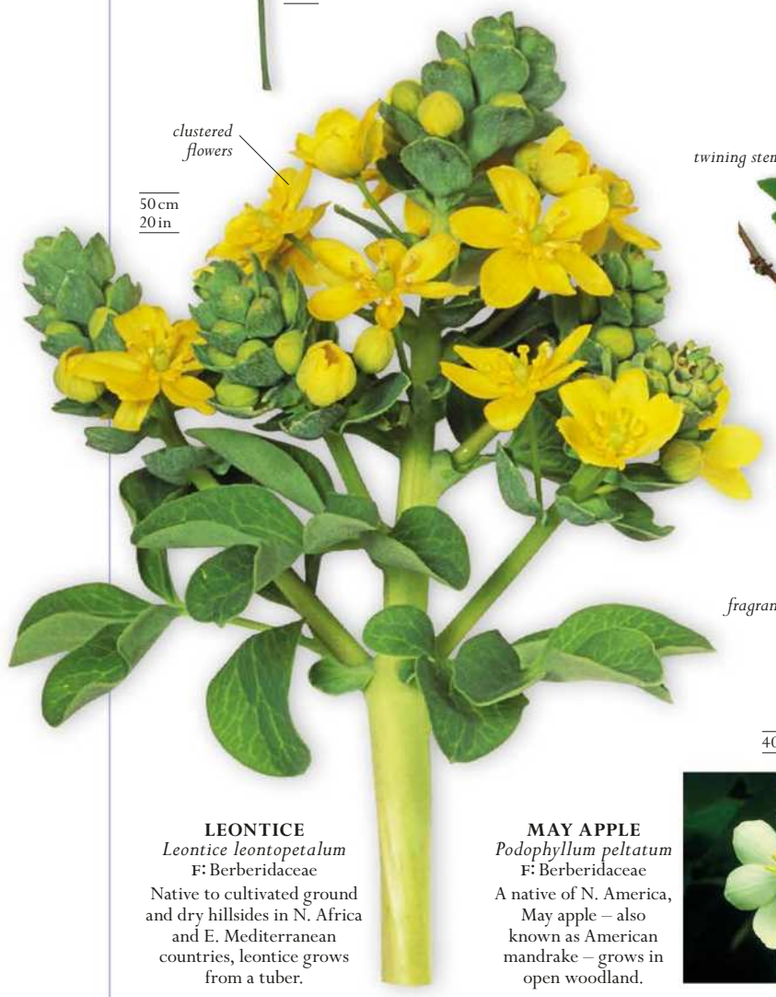
Also called heavenly bamboo, this shrub from mountain valleys in China and Japan is unrelated to true bamboos.

BISHOP'S HAT
Epimedium davidii
F: Berberidaceae

This evergreen species from W. China grows in woods and scrub. The young leaves are coppery, later turning green.

BARBERRY
Berberis vulgaris
F: Berberidaceae

A European species of hedges and scrub, barberry has distinctive triple spines, hanging flower clusters, and red berries.



MOONSEED
Menispermum canadense
F: Menispermaceae

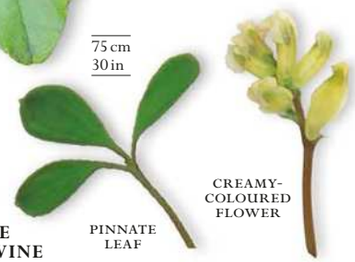
Although the fruits of this climber resemble black grapes, they are extremely poisonous. The species inhabits woodland and banks of streams in Canada and USA.

CAROLINA SNAILSEED
Cocculus carolinus
F: Menispermaceae

This climbing woodland species from S.E. USA has tiny flowers; the males and females are borne on separate plants.

CHOCOLATE VINE
Akebia quinata
F: Lardizabalaceae

Bearing sprays of scented flowers in spring, chocolate vine inhabits forest edges in China, Korea, and Japan.



CLIMBING CORYDALIS
Ceratocapnos claviculata
F: Papaveraceae

This scrambling annual species from W. Europe grows in woods and shady habitats on acid soils, supporting itself by leaf tendrils.

LEONTICE
Leontice leontopetalum
F: Berberidaceae

Native to cultivated ground and dry hillsides in N. Africa and E. Mediterranean countries, leontice grows from a tuber.

MAY APPLE
Podophyllum peltatum
F: Berberidaceae

A native of N. America, May apple – also known as American mandrake – grows in open woodland.

JAPANESE STAUNTON VINE
Stauntonia hexaphylla
F: Lardizabalaceae

Native to woodland in Japan and South Korea, this vigorous evergreen climber has woody stems and fragrant flowers.

YELLOW CORYDALIS
Pseudofumaria lutea
F: Papaveraceae
This European species grows on walls and in stony and rocky places. It spreads vigorously by seed.

GREATER CELANDINE
Chelidonium majus
F: Papaveraceae
Formerly grown by herbalists, greater celandine is native to Europe and N. Asia, growing in woodland, scrub, and rocky places.

YELLOW HORNED POPPY
Glaucium flavum
F: Papaveraceae
Native to W. Europe and the Mediterranean, this biennial or perennial grows on coastal shingle. Its long, curved fruits are distinctive.

BLEEDING HEART
Lamprocapnos spectabilis
F: Papaveraceae
Named for its heart-shaped flowers, this species grows in damp woodland edges in Siberia, N. China, and Korea.

CALIFORNIA POPPY
Eschscholzia californica
F: Papaveraceae
Native to open habitats in western USA and Mexico, this poppy is grown in gardens for its brightly coloured flowers.

MATILIJA POPPY
Romneya coulteri
F: Papaveraceae
A species of scrub and grassland in California and Mexico, this poppy has fragrant flowers and is often grown in gardens.

COMMON FUMITORY
Fumaria officinalis
F: Papaveraceae
Found in Europe and N. Africa on cultivated and waste ground, this species usually grows on light soils.

SICKLEFRUIT HYPECOUM
Hypecoum imberbe
F: Papaveraceae
This Mediterranean native grows in cultivated and waste ground and on walls.

COMMON POPPY
Papaver rhoeas
F: Papaveraceae
Arable and waste ground are home to this poppy, native to Europe, N. Africa, and parts of Asia. It is used as a symbol to commemorate World War I.

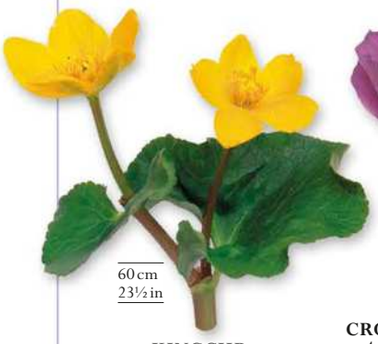
OPIUM POPPY
Papaver somniferum
F: Papaveraceae
Grown as the source of opium, heroin, and poppy seed, this inhabits cultivated and disturbed ground in Eurasia.

WELSH POPPY
Papaver cambrica
F: Papaveraceae
Inhabiting shady, rocky places in hilly areas and often grown in gardens, Welsh poppy is native to W. Europe.

»

PHEASANT'S EYE
Adonis annua
F: Ranunculaceae
An increasingly uncommon annual species, pheasant's eye is found in cultivated and waste ground in W. Europe and N.W. Africa.

MEADOW BUTTERCUP
Ranunculus acris
F: Ranunculaceae
Found in much of Europe and temperate regions of W. Asia, this perennial species is found in damp grassland.



KINGCUP
Caltha palustris
F: Ranunculaceae
Kingcup, or marsh marigold, inhabits marshes, ditches, wet woods, and wet grassland in much of Europe, Asia, and N. America.

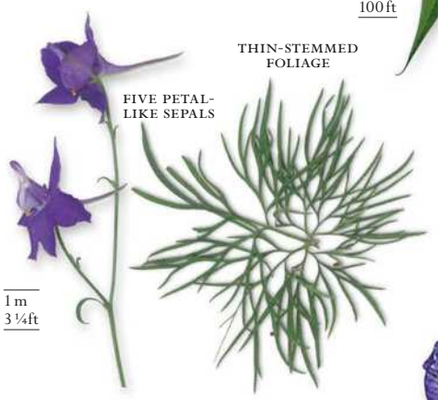
CROWN ANEMONE
Anemone coronaria
F: Ranunculaceae
Mediterranean countries are home to crown anemone, a tuberous perennial species which grows on stony hillsides, roadsides, and cultivated ground.

PASQUE FLOWER
Pulsatilla vulgaris
F: Ranunculaceae
Chalk slopes with short turf are the home of pasque flower, a perennial species native to Europe and W. Asia.

SCARLET LARKSPUR
Delphinium cardinale
F: Ranunculaceae
Also known as cardinal larkspur where it grows in California, USA, and Baja California, Mexico, this short-lived perennial is found on dry hillsides.

FIELD LOVE-IN-A-MIST
Nigella arvensis
F: Ranunculaceae
This annual species is native to cultivated and disturbed ground in C. and S. Europe. It sprouts in gardens elsewhere from spilled bird seed.

TRAVELLER'S JOY
Clematis vitalba
F: Ranunculaceae
Also known as "old man's beard" for its grey, feathery fruits, traveller's joy is a woody climber found in wood edges and hedgerows in Europe and N. Africa.



ROCKET LARKSPUR
Delphinium ambiguum
F: Ranunculaceae
Growing on cultivated and disturbed ground on light soils, rocket larkspur is an annual native to the Mediterranean region.

COMMON MEADOW RUE
Thalictrum flavum
F: Ranunculaceae
This perennial species grows in wet meadows and fens beside fresh water in Europe and temperate regions of Asia.

WINTER ACONITE
Eranthis hyemalis
F: Ranunculaceae
This tuberous perennial species is found in damp woodland and shady places in C. Europe. It flowers in late winter (hence its common name) and early spring.

MONKSHOOD
Aconitum napellus
F: Ranunculaceae
Named for its helmeted flowers, monkshood inhabits damp woods and streamsides in Europe. It is an extremely poisonous perennial species.

HELLEBORE
Helleborus lividus
F: Ranunculaceae
The Balearic Islands, particularly Mallorca, are home to this perennial species. Hellebore inhabits woods and rocky hillsides.

GLOBEFLOWER
Trollius europaeus
F: Ranunculaceae
Native to Europe and W. Asia, globeflower is a perennial species found in damp mountain pasture.

HEPATICA
Hepatica nobilis
F: Ranunculaceae
Native to much of Europe, this perennial woodland species has distinctive semi-evergreen, three-lobed leaves.

COLUMBINE
Aquilegia vulgaris
F: Ranunculaceae
A perennial species native to much of Europe, N. Africa, and temperate regions of Asia, columbine is found in shady and damp chalky habitats.

MOUSETAIL
Myosurus minimus
F: Ranunculaceae
The "tail" of mousetail is the elongated fruit that develops from its flower. This species grows in bare damp ground across Europe, Asia, and N. America.

GUNNERALES

The two families which make up the Gunnerales order were previously classified in different orders, as they are visually very different. However, genetic analysis has recently shown the two families to be closely related. The family Gunneraceae consists of a single genus of large herbaceous plants growing in damp habitats, whereas Myrothamnaceae species are inhabitants of African deserts. *Gunnera* species are often grown in gardens as ornamental plants.

GUNNERA
Gunnera manicata
F: Gunneraceae
Massive leaves and tall flower spikes characterize this perennial species. It is native beside fresh water in S. Brazil.

DILLENIALES

The order Dilleniales contains only the Dilleniaceae, a mainly tropical family of around 330 species of trees, shrubs, and climbers. Most species have alternately arranged leaves and bisexual flowers (with male and female parts), with five sepals, five petals, and numerous stamens. Some produce dry fruits that open to shed their seeds, others have berries. A few are grown as ornamentals or for timber used in construction and boat building.

GOLDEN GUINEA VINE
Hibbertia scandens
F: Dilleniaceae
A vigorous climber or scrambler, this evergreen shrub grows near the E. coast of Australia and in New Guinea.

SIMPOH AIR
Dillenia suffruticosa
F: Dilleniaceae
A large and vigorous evergreen shrub endemic to Malaysia, Sumatra, and Borneo, simpoh air is found on swampy ground and forest edges.

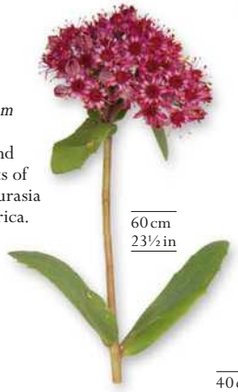
SAXIFRAGALES

Of the 15 diverse families in the Saxifragales, five have just two members each and only three have more than 500 species. Best known is the saxifrage family, after which the order is named. The Latin *saxifraga* literally means "rock breaker", as these plants often grow in cracks in rocks and walls. The largest family is the stonecrops, Crassulaceae, which includes many succulent or water-retaining plants, adapted to dry conditions.

MEXICAN FIRECRACKER
Echeveria setosa
F: Crassulaceae
Named for its flame-coloured flowers, this Mexican species has rosettes of succulent, blue-green, variably downy leaves.

COMMON HOUSELEEK
Sempervivum tectorum
F: Crassulaceae
Originating from mountains in C. Europe, houseleek is often planted on roofs and walls. This plant forms dense mats of succulent rosettes.

SAUCER PLANT
Aeonium tabuliforme
F: Crassulaceae
This native of cliffs on the N. coast of Tenerife, Canary Islands, forms a flat, succulent leaf rosette.



ORPINE
Hylotelephium telephium
F: Crassulaceae
Rocky terrain, woods, and hedgebanks are the habitats of orpine, a species native to Eurasia and introduced to N. America.

FLAMING KATY
Kalanchoe blossfeldiana
F: Crassulaceae
Arid areas of Madagascar are home to this bushy species with glossy succulent leaves and brightly coloured flowers.

NAVELWORT
Umbilicus rupestris
F: Crassulaceae
This species has round, fleshy leaves, each with a central dimple. Navelwort inhabits rocks and walls in S. Europe and N. Africa.

ROSEROOT
Rhodiola rosea
F: Crassulaceae
Inhabiting mountain rocks and coastal cliffs, roseroot is a fleshy species found in the Arctic and alpine regions in Europe, N. America, and Asia.

BLACKCURRANT
Ribes nigrum
F: Grossulariaceae
This species grows in damp woods in much of Europe and C. Asia. Blackcurrant is cultivated for its flavoursome berries.

BUFFALO CURRANT
Ribes aureum
F: Grossulariaceae
Scented flowers and thornless stems characterize buffalo currant, an inhabitant of rocky and sandy areas in C. USA.

WESTERN WATER MILFOIL
Myriophyllum hippuroides
F: Haloragaceae
This aquatic species has finely divided leaves. It is native to freshwater habitats in western N. America.

12 m
40 ft

CHINESE SWEETGUM
Liquidambar formosana
F: Altingiaceae
A deciduous tree of damp woodland in S.W. Asia, this species is noted for its brightly coloured autumn foliage.

6 m/20 ft

PARROTIOPSIS
Parrotiopsis jacquemontiana
F: Hamamelidaceae
Instead of petals, the flowers of this forest species from the W. Himalayas have white bracts, or modified leaves.

BUDS AND FLOWERS

LEAVES CHANGING COLOUR

10 m/33 ft

VIRGINIAN WITCH HAZEL
Hamamelis virginiana
F: Hamamelidaceae
The flowers of this witch hazel are fragrant and the leaves turn yellow in autumn. It inhabits woodland in eastern N. America.

1 m/3¼ ft

CHINESE ASTILBE
Astilbe rubra
F: Saxifragaceae
With distinctive plume-like clusters of flowers, this moisture-loving plant grows in damp woodland and by streams from Myanmar to Siberia.

20 cm
8 in

15 m/50 ft

PERSIAN IRONWOOD
Parrotia persica
F: Hamamelidaceae
Native to forests in the Caucasus region and northern Iran, Persian ironwood is a winter-flowering deciduous tree with brilliantly coloured autumn leaves.

MOTHER OF THOUSANDS
Saxifraga stolonifera
F: Saxifragaceae
Native to shady habitats in China and Japan, this perennial spreads by producing rooting plantlets at the end of thread-like runners.

30 cm
12 in

YELLOW SAXIFRAGE
Saxifraga aizoides
F: Saxifragaceae
Streamsides and wet stony ground on mountains are home to this cushion-forming species from Europe, N. America, and W. Asia.

60 cm/23½ in

ALUMROOT
Heuchera americana
F: Saxifragaceae
Inhabiting rocky woodland in N. America, alumroot has glossy leaves which are mottled when young.

flowers form in a flattish-topped cluster

ELEPHANT'S EARS
Bergenia stracheyi
F: Saxifragaceae
An inhabitant of damp woodland and meadows in the W. Himalayas and Afghanistan, elephant's ears has fragrant flowers and large, glossy leaves.

30 cm
12 in

large, glossy leaf

15 cm/6 in

70 cm
28 in

OPPOSITE-LEAVED GOLDEN-SAXIFRAGE
Chrysosplenium oppositifolium
F: Saxifragaceae
The procumbent stems of this species form extensive patches in damp shady habitats in W. and C. Europe.

COMMON PEONY
Paeonia officinalis
F: Paeoniaceae
A herbaceous species found in woodland, meadows, and scrub in parts of S. Europe, common peony is known for its showy flowers.

70 cm
28 in

PIGGYBACK PLANT
Tolmiea menziesii
F: Saxifragaceae
Young plantlets growing on leaf bases give piggyback plant its name. It is a hairy perennial species found in damp shady places in N. America.

VITALES

This order consists of a single family, the Vitaceae or grape family. It contains 14 genera and 850 species, including the important grapevine and the ornamental Virginia creeper. Members of the Vitaceae are mainly native to the tropics or warm temperate regions. Mostly vines or lianas, they usually have swollen nodes (where leaves fork from the stem) and tendrils for climbing. Their flowers are usually held in flat-topped clusters.

GRAPEVINE
Vitis vinifera
F: Vitaceae
Humans have used grapes to make wine, food, and medicine since neolithic times. Very widespread, the grapevine is native to the Mediterranean, Europe, and Asia.

35 m
115 ft

fruits smaller than domesticated varieties

CRIMSON GLORY VINE
Vitis coignetiae
F: Vitaceae
Cultivated for its giant, dimpled leaves (30 cm/12 in across) and autumn colour, this deciduous climber is native to temperate Asia.

15 m
50 ft

VIRGINIA CREEPER
Parthenocissus quinquefolia
F: Vitaceae
This prolific climber from N. and C. America clings on to smooth surfaces using the adhesive pads on its small, forked tendrils.

foliage turns red in the autumn

30 m
100 ft

GERANIALES

Two families comprise the Geraniales order. The Geraniaceae or geranium family contains around 800 species, including 400 cranesbills in the genus *Geranium*. Many of the 200 species in the African genus *Pelargonium* are of horticultural importance, including the garden plants called geraniums. The new family Francoaceae encompasses four previously recognised families, mainly of trees and shrubs from Africa.

2.5 m
8 ft

GIANT HONEYBUSH
Melianthus major
F: Francoaceae
Nectar drips from the bronze flower spikes of this South African native. Touching the leaves causes them to give off a strong odour.

30 cm
12 in

APPLE PELARGONIUM
Pelargonium odoratissimum
F: Geraniaceae
This perennial originates from South Africa and has spreading flower stalks. It is cultivated for geranium oil, which has a strong scent of apple and rose.

50 cm
20 in

HERB ROBERT
Geranium robertianum
F: Geraniaceae
Widespread in the northern hemisphere, this sprawling species has red stems and long flower stalks. It has a strong, mousey smell.

80 cm
32 in

MEADOW CRANESBILL
Geranium pratense
F: Geraniaceae
Preferring grasslands on chalky soil, this perennial is native to Europe and Asia. Its flowers are pollinated by honey bees and other wild bee species.

20 cm
8 in

ROCK STORKSBILL
Erodium foetidum
F: Geraniaceae
Storksbills take their name from the shape of their seeds. This French native is cultivated in rock gardens.

MYRTALES

The nine families in the Myrtales are most common in warmer regions. The 5,800 species in the Myrtaceae or myrtle family provide essential oils, spices, and fruits such as guava. They include over 700 species of eucalypts from Australia and New Guinea. The Lythraceae or loosestrife family consists mainly of tropical trees and shrubs, producing fruits such as pomegranate and various dyes, and the Melastomataceae is a pan-tropical family of around 4,500 trees, shrubs, and climbers.

CRAPE MYRTLE
Lagerstroemia indica
F: Lythraceae
Blooming for up to 120 days, this tree is native to China, Korea, and Japan. Its bark is smooth, mottled, pinkish-grey, and is shed each year.

HENNA
Lawsonia inermis
F: Lythraceae
Native to N. Africa and the Middle East, henna's leaves make a reddish-brown dye and its fragrant flowers yield essential oils.

SWAMP LOOSESTRIFE
Decodon verticillatus
F: Lythraceae
Native to N.E. America, this shrub grows in swamps. It has arching stems with leaves in whorls of three, and red or purple flowers up to 2.5 cm (1 in) across.

WATER CHESTNUT
Trapa natans
F: Lythraceae
This floating plant is from Europe and Asia. It has an edible starchy seed in a nut with four horn-like barbed spines.

POMEGRANATE
Punica granatum
F: Lythraceae
This spiny, shrubby tree, from S.W. Asia, is widely cultivated in the Mediterranean for its pulpy fruits, containing numerous seeds.

PURPLE LOOSESTRIFE
Lythrum salicaria
F: Lythraceae
Numerous purple-red, square stems grow from the woody, creeping rootstock of this perennial. Native to Europe, Asia, S.E. Australia, and N.W. Africa, it can be invasive.

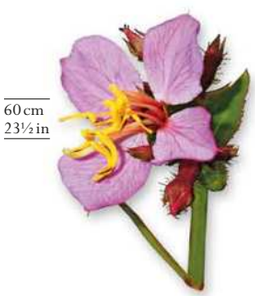
CIGAR FLOWER
Cuphea ignea
F: Lythraceae
A densely branched, perennial shrub, cigar flower is a garden and house ornamental, native to Mexico. Its fruits are paper-like capsules.

RANGOON CREEPER
Combretum indicum
F: Combretaceae
This climber from tropical Asia has clusters of tubular red flowers. Its ellipsoidal fruits, each with five wings, taste of almonds.

INDIAN ALMOND
Terminalia catappa
F: Combretaceae
Found on coasts of the Indo-Pacific oceans, this tree has horizontal branches. Its corky fruit, dispersed by water, contains an edible, almond-tasting nut.

ROSE GRAPE
Medinilla magnifica
F: Melastomataceae
This ornamental from the Philippines is an epiphyte, growing on trees. Its leaves have the longitudinal veins characteristic of the melastomes.

BRAZILIAN SPIDER FLOWER
Tibouchina urvilleana
F: Melastomataceae
In warm regions this Brazilian ornamental blooms for most of the year. Its velvety leaves have red edges and three to five obvious longitudinal veins.



VIRGINIA MEADOW BEAUTY
Rhexia virginica
F: Melastomataceae
This hairy, perennial herb from E. USA and Canada grows on wetlands. It has square stems and stalkless leaves with toothed margins.

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GREEN BOTTLEBRUSH
Melaleuca virens
F: Myrtaceae
Resisting snow, frost, and drought, this sprawling subalpine shrub from Tasmania has leaves with sharp, pointed ends. It attracts birds and butterflies.

TONGHI BOTTLEBRUSH
Melaleuca subulata
F: Myrtaceae
A spreading shrub with small, woody fruits containing hundreds of seeds. It is found mainly in New South Wales and Victoria, Australia.

RED GUM
Eucalyptus camaldulensis
F: Myrtaceae
Widespread in Australia, with smooth, pale bark and blue-green leaves, this riverside tree has durable timber and its nectar makes good honey.

TASMANIAN SNOW GUM
Eucalyptus coccifera
F: Myrtaceae
With grey-white bark, peeling in long strips to reveal a creamy-white trunk, this species of Tasmanian uplands has unstalked, opposite leaves.

CIDER GUM
Eucalyptus gunnii
F: Myrtaceae
This hardy Tasmanian tree forms juvenile leaves that are round and silvery, maturing to scythe-shaped and blue-grey. It is used in paper production.

CAJUPUT
Melaleuca cajuputi
F: Myrtaceae
Native from S.E. Asia to N. Australia, this tree has aromatic leaves that contain a pale yellow medicinal oil.

COMMON MYRTLE
Myrtus communis
F: Myrtaceae
Native from the Mediterranean to Pakistan, myrtle produces fragrant flowers and blue-black berries. Its aromatic leaves yield essential oils.

ALLSPICE
Pimenta dioica
F: Myrtaceae
From the Caribbean, S. Mexico, and C. America, this unisexual tree has small, white flowers that form brown, berry-like stoned fruits. Unripe fruits are dried and ground to make "allspice".

URN-FRUITED GUM
Eucalyptus urnigera
F: Myrtaceae
This tree from S.E. Tasmania has urn-shaped fruits, blue-grey juvenile leaves, and white flowers in clusters of three with numerous stamens.

CHILEAN MYRTLE
Luma apiculata
F: Myrtaceae
This slow-growing tree has a contorted trunk and smooth grey-orange peeling bark. Its fruit is a black berry.

SCARLET KUNZEA
Kunzea baxteri
F: Myrtaceae
Kunzea species are unusual in having colourful stamens much longer than their petals, which adds to the showy appearance that attracts pollinating birds.

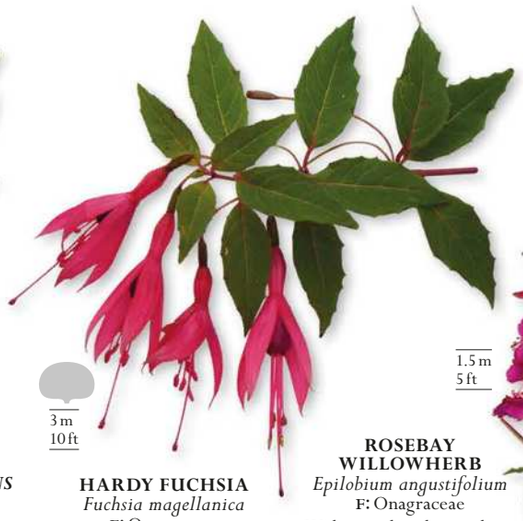
GUAVA
Psidium guajava
F: Myrtaceae
This tree from tropical and subtropical America has flaky, coppery bark. The fruits have a sweet, musky smell when ripe, and contain numerous hard, yellow seeds.

POHUTAKAWA
Metrosideros excelsa
F: Myrtaceae
Native to North Island, New Zealand, this tree produces red flowers in December. Old trees have beard-like masses of hanging aerial roots.

CLOVE
Syzygium aromaticum
F: Myrtaceae
The dried flower buds of this native of Indonesian islands are used as a spice. Its cream-coloured flowers have red stamens and ripen to purple, single-seeded berries.

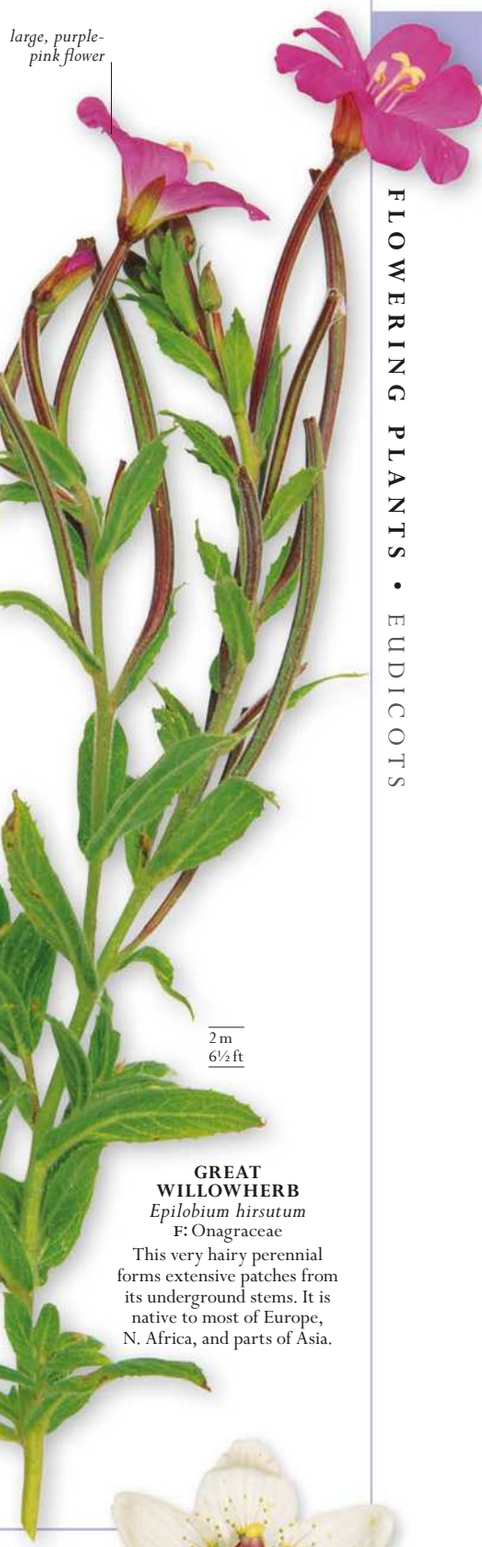
GODETIA
Clarkia amoena
F: Onagraceae
This annual is native to coastal hills of western N.America. Cultivated in gardens, its flower has four broad petals and forms a dry capsule, containing numerous seeds.

FUCHSIA FULGENS
F: Onagraceae
Typically found clinging to rocks or tree branches by its long, tuberous roots, this deciduous shrub grows near water in the mountains of Mexico.



HARDY FUCHSIA
Fuchsia magellanica
F: Onagraceae
This widely planted deciduous, ornamental perennial originates from Chile and Argentina, where it usually grows with its roots in water.

ROSEBAY WILLOWHERB
Epilobium angustifolium
F: Onagraceae
Widespread in the northern hemisphere, this herbaceous perennial proliferates by spreading its roots and wind-dispersed seeds. Some taxonomists put it in the genus *Chamerion* or *Chamaenerion*.



GREAT WILLOWHERB
Epilobium hirsutum
F: Onagraceae
This very hairy perennial forms extensive patches from its underground stems. It is native to most of Europe, N. Africa, and parts of Asia.

ENCHANTER'S NIGHTSHADE
Circaea lutetiana
F: Onagraceae
This woodland plant is found in Europe, N. Africa, and the Middle East. Flowers of two sepals and two notched petals form small, round, hairy fruits.

SHOWY EVENING PRIMROSE
Oenothera speciosa
F: Onagraceae
This herbaceous, smooth-stemmed perennial is from S.E. USA and Mexico. Its white flowers become pink with age and close in full sun.

EVENING PRIMROSE
Oenothera biennis
F: Onagraceae
This biennial from eastern N. America has bluish green leaves in a basal rosette and erect stems bearing flowers that open in the evening. The seed oil has medicinal properties.

SEEDBOX
Ludwigia alternifolia
F: Onagraceae
Native to eastern N. America, this is a plant of damp places. It has box-shaped seed pods borne on angled stems.

CELASTRALES

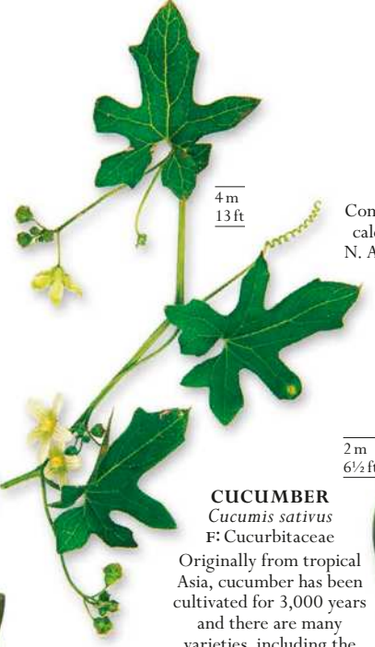
The two families in this order are characterized by a nectar-secreting disc in the flower. The Lepidobotryaceae comprises just two tropical tree species, but the Celastraceae or spindle tree family has 1,200 species, mainly of vines, shrubs, and trees. Genetic analysis is yet to determine how the Celastrales order relates to other rosids.

SPINDLE TREE
Euonymus europaeus
F: Celastraceae
Native to Europe, the wood of this tree was used to make spindles – spikes used to spin thread. Its fruits ripen to red and split into four to reveal orange-coated, poisonous seeds.

GRASS OF PARNASSUS
Parnassia palustris
F: Celastraceae
This rosette plant grows in bogs in the northern temperate zone. Each flower is borne on a stem, clasped by a stalkless leaf.

CUCURBITALES

Eight, mainly tropical families of trees, shrubs, herbs, and climbers make up this order. Six have few members, but the Begoniaceae or begonia family has 1,400 species, 130 of which are horticultural plants. The 850 species in the Cucurbitaceae or gourd family include notable food plants such as squash and pumpkins. Both of these families have male and female flowers on the same plant (monoecious).



WHITE BRYONY
Bryonia cretica ssp. *dioica*
F: Cucurbitaceae
Common in hedgerows and scrub on calcium-rich soils in S. Europe and N. Africa, this poisonous climber has a swollen, tuberous root.

CUCUMBER
Cucumis sativus
F: Cucurbitaceae
Originally from tropical Asia, cucumber has been cultivated for 3,000 years and there are many varieties, including the gherkin. The plant has tubular yellow flowers.

SQUASH
Cucurbita pepo
F: Cucurbitaceae
With five-sided prickly stems and large yellow-orange flowers, pumpkins, marrows, and courgettes are all varieties of *Cucurbita pepo* from C. America.

SMOOTH LOOFAH
Luffa cylindrica
F: Cucurbitaceae
This climbing, annual vine, originally from Asia, produces cylindrical fruits. Their fibrous interior can be eaten young, or dried and used as a sponge.

CALABASH
Lagenaria siceraria
F: Cucurbitaceae
5 m
16 ft
This vine produces whitish crinkly flowers. Its edible, hard-shelled fruit floats in the sea for months and is used as a container.

SQUIRTING CUCUMBER
Ecballium elaterium
F: Cucurbitaceae
The ripe fruit of this Mediterranean plant becomes so swollen with juices that it explodes when touched, squirting its seeds up to 6 m (20 ft).

WATERMELON
Citrullus lanatus
F: Cucurbitaceae
With yellow-green flowers, this annual, prostrate vine originated in southern Africa and its fruits are cultivated throughout warmer climates.

BEGONIA LISTADA
F: Begoniaceae
Native to Paraguay, this sprawling species sprawls, has thick, velvety leaves with a red underside, and white-pinkish flowers. It was first described in 1981.

BALSAM PEAR
Momordica charantia
F: Cucurbitaceae
Also called bitter gourd, this tropical vine produces bitter-tasting fruits. Their tips split into three to reveal yellow pulp and seeds encased in scarlet coats (arils).

3 m
10 ft

45 m
150 ft

TETRAMELES NUDIFLORA
F: Datiscaceae
Props at the trunk base support this tall tree from Asia and N. Australia. Male flowers grow on different trees to the female flowers, which form round seed capsules.

FABALES

Found all over the world, except for Antarctica, the Fabales have compound leaves with tiny outgrowths (stipules) at the base and seed pods that open when mature. Called legumes, these plants have nodules – swellings that contain bacteria – on their roots that help them fix nitrogen from the air into soil. The Fabaceae, the largest of the four families, includes plants like the pea with flowers that have a large upper petal with adjacent smaller petals.

SENSITIVE PLANT
Mimosa pudica
F: Fabaceae

This prickly S. American plant's leaves close when touched. Its flowerheads (1 cm/⅜ in) usually have pink flowers and long, pink-purple stamens.

PEANUT
Arachis hypogaea
F: Fabaceae

Native to Brazil, this legume has yellow, reddish veined pea-like flowers. Its seed pod matures in the ground, producing peanuts.

SILVER WATTLE
Acacia dealbata
F: Fabaceae

This tree has fragrant flowers and silvery bark, ageing to black. Native to S.E. Australia, silver wattle is often called mimosa elsewhere.

SAINFOIN
Onobrychis viciifolia
F: Fabaceae

This fodder crop from S. Europe has green, oval, pinnate leaves with 6–14 pairs of leaflets. Densely packed pink flowers appear on a main stem.

GOLDEN SHOWER TREE
Cassia fistula
F: Fabaceae

This slender tree from S.E. Asia has pendulous, pea-like flowers and pinnate leaves with three to eight pairs of leaflets. Its seeds are poisonous.

WEST INDIAN LOCUST TREE
Hymenaea courbaril
F: Fabaceae

This hardwood tree has a straight, thick trunk and stems of white-purplish flowers with large petals and long stamens. Orange gum oozes from its trunk, which is used in incense and perfumes.

flowers are clusters of stamens with reduced petals

KIDNEY VETCH
Anthyllis vulneraria
F: Fabaceae

A plant of dry, grassy places throughout Europe, this perennial has silky-haired stems and clusters of yellow to red flowers, with a ruff of downy bracts beneath.

TAMARIND
Tamarindus indica
F: Fabaceae

This evergreen tree with drooping branches from East Africa and Asia has yellow-orange flowers on stems and edible pulp inside the seed pod.

FLAT WATTLE
Acacia glaucoptera
F: Fabaceae

The globular flowers of this spreading shrub from S.W. Australia grow from a modified stem looking like a twisted leaf.

leaf with 6–12 pairs of pinnate leaflets

SILK TREE
Albizia julibrissin
F: Fabaceae

This deciduous tree is native to S.W. Asia. It has dark green bark, striped vertically with age, and is fast-growing but short lived.

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WILD LIQUORICE
Astragalus glycyphyllos
F: Fabaceae

With similar leaves to true liquorice, this European grassland herb has curved pods. It can be used as a tea.

BLUE FALSE INDIGO
Baptisia australis
F: Fabaceae

The sap of this herbaceous perennial, native to woods and streamsides in E. USA, turns purple when exposed to air, and is used as an indigo dye substitute.

BLACK BEAN TREE
Castanospermum australe
F: Fabaceae

The orange-and-red flowers of this Australian timber tree develop into woody pods containing three to five bean-like seeds.

CAROB TREE
Ceratonia siliqua
F: Fabaceae

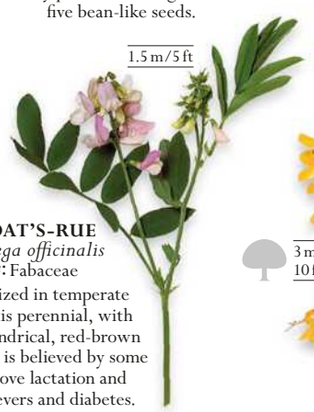
This Mediterranean tree has a thick trunk, dense foliage, and small, dull-green flowers. Pulp from the seed pods is a chocolate substitute.

JUDAS TREE
Cercis siliquastrum
F: Fabaceae

This deciduous, ornamental and timber tree from the E. Mediterranean flowers profusely in the spring, then later develops flat 10 cm (4 in) seed pods.

CHICK PEA
Cicer arietinum
F: Fabaceae

One of the earliest cultivated vegetables from the Middle East, its seed pod contains one to three seeds, which can be cooked to make hummus.

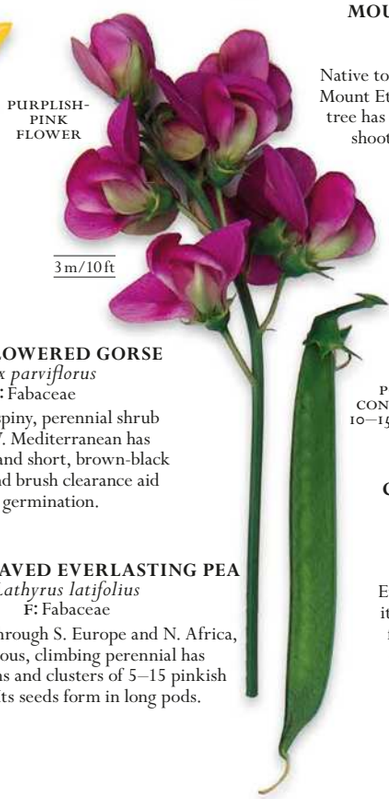


GOAT'S-RUE
Galega officinalis
F: Fabaceae

Naturalized in temperate areas, this perennial, with long, cylindrical, red-brown seed pods, is believed by some to improve lactation and reduce fevers and diabetes.

MOUNT ETNA BROOM
Genista aetnensis
F: Fabaceae

Native to Sicily, around the slopes of Mount Etna, and Sardinia, this small tree has few leaves; flattened green shoots assist photosynthesis.



SMALL-FLOWERED GORSE
Ulex parviflorus
F: Fabaceae

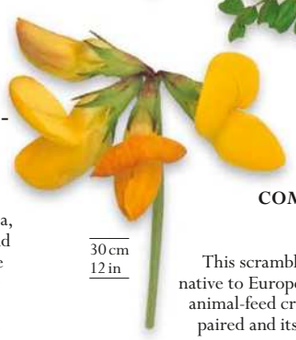
This dense, spiny, perennial shrub from the W. Mediterranean has yellow leaves and short, brown-black pods. Fire and brush clearance aid seed germination.

BROAD-LEAVED EVERLASTING PEA
Lathyrus latifolius
F: Fabaceae

Distributed through S. Europe and N. Africa, this vigorous, climbing perennial has winged stems and clusters of 5–15 pinkish flowers. Its seeds form in long pods.

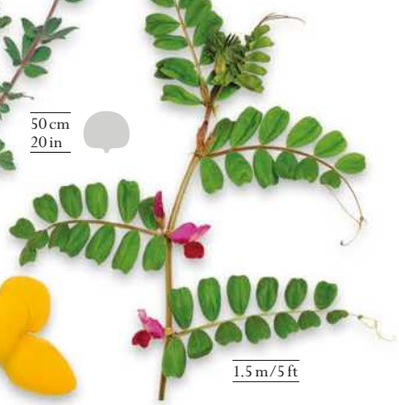
DORYCNIUM
Lotus hirsutus
F: Fabaceae

This Mediterranean perennial forms grey-green shrubby mounds. Its red-brown cylindrical pods can be mistaken for small berries.



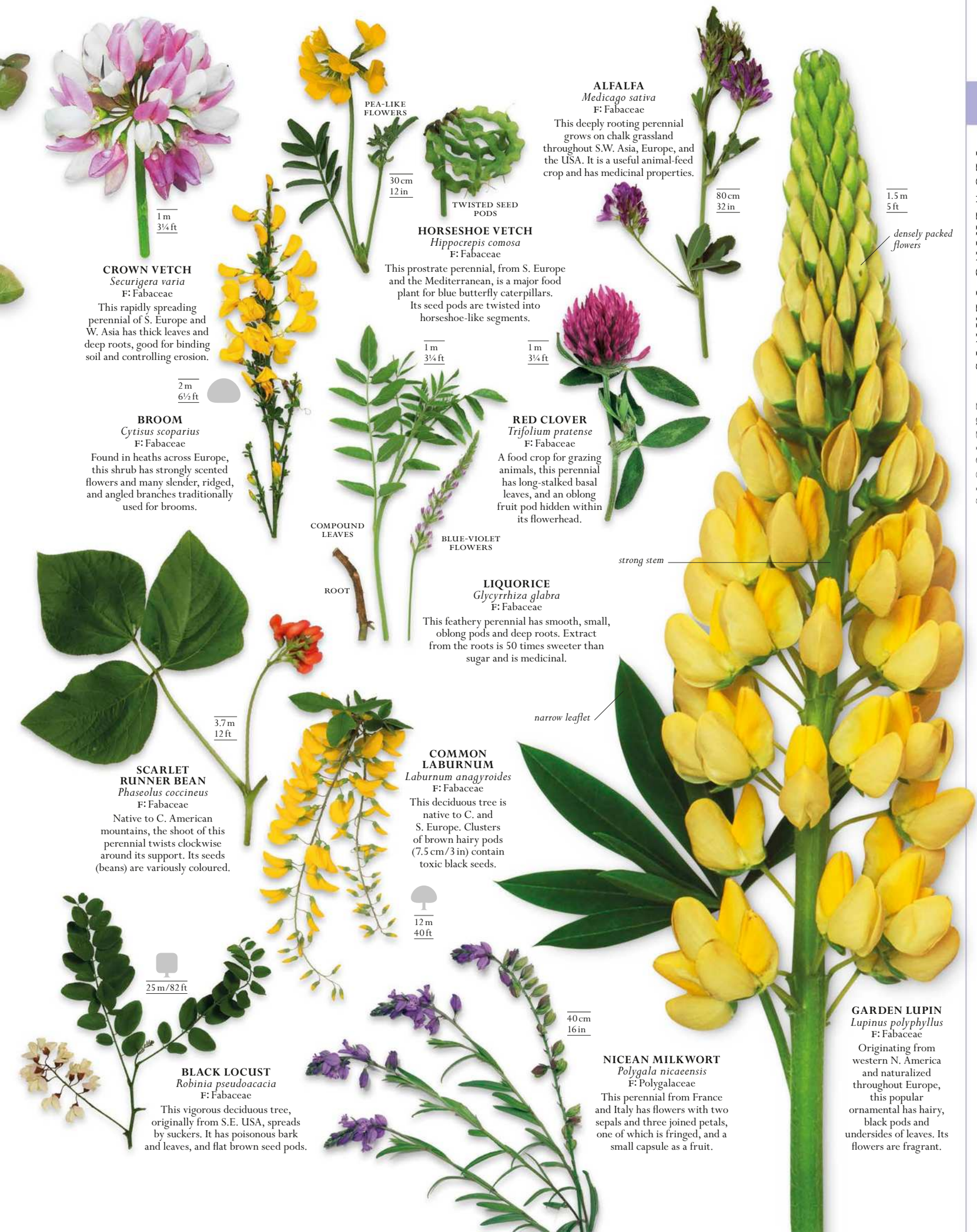
COMMON BIRD'S-FOOT TREFOIL
Lotus corniculatus
F: Fabaceae

Found in grassland in Europe, Asia, and Africa, it has yellow flowers and five lobed leaves, three of which sit above the others. Its seed pods resemble a bird's foot.



COMMON VETCH
Vicia sativa
F: Fabaceae

This scrambling, widespread annual is native to Europe and the Mediterranean. An animal-feed crop, its flowers are normally paired and its tendrils can be branched.



CROWN VETCH
Securigera varia
F: Fabaceae
This rapidly spreading perennial of S. Europe and W. Asia has thick leaves and deep roots, good for binding soil and controlling erosion.

HORSESHOE VETCH
Hippocrepis comosa
F: Fabaceae
This prostrate perennial, from S. Europe and the Mediterranean, is a major food plant for blue butterfly caterpillars. Its seed pods are twisted into horseshoe-like segments.

ALFALFA
Medicago sativa
F: Fabaceae
This deeply rooting perennial grows on chalk grassland throughout S.W. Asia, Europe, and the USA. It is a useful animal-feed crop and has medicinal properties.

BROOM
Cytisus scoparius
F: Fabaceae
Found in heaths across Europe, this shrub has strongly scented flowers and many slender, ridged, and angled branches traditionally used for brooms.

RED CLOVER
Trifolium pratense
F: Fabaceae
A food crop for grazing animals, this perennial has long-stalked basal leaves, and an oblong fruit pod hidden within its flowerhead.

LIQUORICE
Glycyrrhiza glabra
F: Fabaceae
This feathery perennial has smooth, small, oblong pods and deep roots. Extract from the roots is 50 times sweeter than sugar and is medicinal.

SCARLET RUNNER BEAN
Phaseolus coccineus
F: Fabaceae
Native to C. American mountains, the shoot of this perennial twists clockwise around its support. Its seeds (beans) are variously coloured.

COMMON LABURNUM
Laburnum anagyroides
F: Fabaceae
This deciduous tree is native to C. and S. Europe. Clusters of brown hairy pods (7.5 cm/3 in) contain toxic black seeds.

BLACK LOCUST
Robinia pseudoacacia
F: Fabaceae
This vigorous deciduous tree, originally from S.E. USA, spreads by suckers. It has poisonous bark and leaves, and flat brown seed pods.

NICEAN MILKWORT
Polygala nicaeensis
F: Polygalaceae
This perennial from France and Italy has flowers with two sepals and three joined petals, one of which is fringed, and a small capsule as a fruit.

GARDEN LUPIN
Lupinus polyphyllus
F: Fabaceae
Originating from western N. America and naturalized throughout Europe, this popular ornamental has hairy, black pods and undersides of leaves. Its flowers are fragrant.

FAGALES

The seven families in this order include some of the world's best-known trees, which dominate the woodlands in which they grow: beech trees in the Fagaceae, birches in the Betulaceae, southern beeches in the Nothofagaceae, walnut trees in the Juglandaceae, and Australian she-oaks in the Casuarinaceae. Most have simple leaves and small, wind-pollinated flowers.

20 m
65 ft

fruit and seed develop from catkins

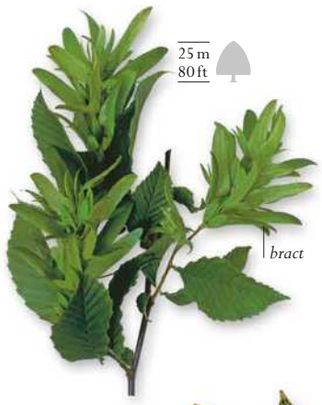
FOREST OAK
Allocasuarina torulosa
F: Casuarinaceae

The timber of this W. Australian tree is prized by wood-turners. Its pendulous branches carry needle-like, green twigs with tiny leaves and warty cones.

25 m
80 ft

JAPANESE HOP HORNBEAM
Ostrya japonica
F: Betulaceae

This species from the Far East has grey-brown scaly bark. Its nutlet seeds are enclosed in husks, like hops, and hang in long clusters.



25 m
80 ft

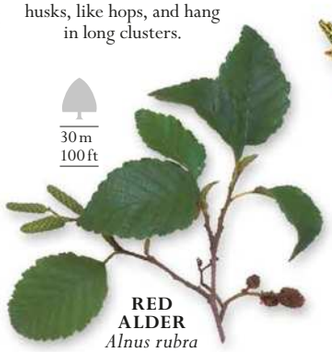
bract

COMMON HORNBEAM
Carpinus betulus
F: Betulaceae

Frequenting hedgerows, this European native has small, green, male and female catkin flowers that develop into nuts surrounded by three-lobed bracts.

male catkin

leaf bud



30 m
100 ft

RED ALDER
Alnus rubra
F: Betulaceae

A native of western N. America, this tree prefers damp slopes and margins of watercourses. It has pale grey bark that becomes red when bruised or scraped.

female flower

13 m
43 ft

HAZEL
Corylus avellana
F: Betulaceae

This European shrubby tree is harvested for its edible nuts. Its male catkins and female flowers appear in early spring.

catkin is a cylindrical cluster of male flowers

25 m
80 ft

RAULI
Nothofagus alpina
F: Nothofagaceae

A timber tree, rauli is native to Argentina and Chile. The young leaves are bronze. Greenish female flowers grow in clusters and form bristly husks enclosing small nuts.

PINNATE LEAVES

40 m
130 ft

RIPE PECAN

PECAN
Carya illinoinensis
F: Juglandaceae

The pecan is native to N. America and cultivated for its edible nuts. The nuts are enclosed in a husk that splits four ways when ripe.

PLATYCARYA STROBILACEA
F: Juglandaceae

Native to E. Asia, this tree has clusters of erect male catkins and a fruit, like a conifer cone, with winged seeds.

15 m
50 ft

30 m
100 ft

BUTTERNUT
Juglans cinerea
F: Juglandaceae

This deciduous tree, native to N. America, has yellow-green catkins. Small bunches of egg-shaped nuts contain sweet seeds.

30 m
100 ft

30 m
100 ft

RIPE WALNUT

LEAF SPRIG WITH UNRIPE FRUITS

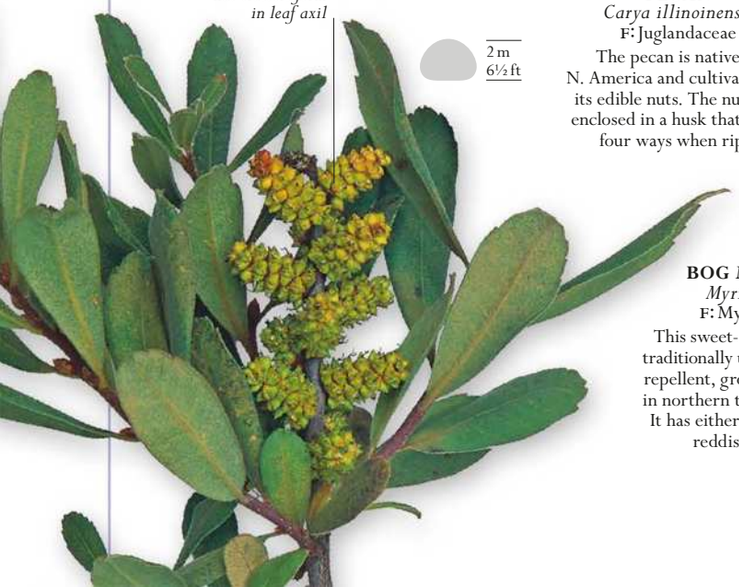
COMMON WALNUT
Juglans regia
F: Juglandaceae

A species from the mountains of S.W. Asia, the walnut tree is valued for its fruits and timber. It has smooth grey bark and male catkins up to 15 cm (6 in) long.

ERMAN'S BIRCH
Betula ermanii
F: Betulaceae

Native to mountain areas from Siberia to Japan, this tree is widely planted in parks and gardens. It has peeling, whitish bark.

nut clusters form in leaf axil



2 m
6½ ft

BOG MYRTLE
Myrica gale
F: Myricaceae

This sweet-smelling shrub, traditionally used as an insect repellent, grows in peat bogs in northern temperate zones. It has either male or female reddish catkins.

ENGLISH OAK
Quercus robur
F: Fagaceae

Long-lived, with valuable timber, this tree is common in W. Europe, especially Britain. It has male flowers in long, hanging catkins, and long-stalked acorns.

SCARLET OAK
Quercus coccinea
F: Fagaceae

The leaves of this N. American tree turn a characteristic deep red in autumn. This oak bears long catkins of yellowish green male flowers and its acorns have a glossy cup.

KERMES OAK
Quercus coccifera
F: Fagaceae

An evergreen, shrubby tree from the Mediterranean area, this species has holly-like leaves that are bronze when young, and yellow-brown male catkins.

JAPANESE STONE OAK
Lithocarpus edulis
F: Fagaceae

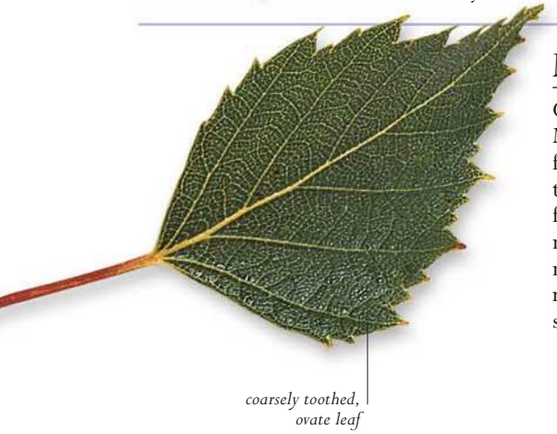
This Japanese evergreen tree has upright creamy-white catkins, which have female flowers at the base and males above. The edible acorns ripen over two years.

AMERICAN BEECH
Fagus grandifolia
F: Fagaceae

This broadly spreading tree from eastern N. America has grey-brown bark. It has glossy deciduous leaves and two fruits (beechnuts) in each husk.

SWEET CHESTNUT
Castanea sativa
F: Fagaceae

Cultivated for 3,000 years for its nuts, this tree is from S.E. Europe and W. Asia. It bears catkins with male flowers in the upper part and female flowers beneath.



MALPIGHIALES

One of the largest and most diverse orders, Malpighiales comprises 36 mainly tropical families with over 16,000 species, grouped together by their DNA but widely different in form. Half the families, including one only recognized in 2016, have fewer than 100 members and many are unfamiliar outside their native regions, but they also include the huge spurge family (Euphorbiaceae), with 6,300 species.

TUTSAN
Hypericum androsaemum
F: Hypericaceae

This small shrub from W. Europe has reddish, two-ridged stems. Its aromatic leaves have medicinal uses, but its berries are poisonous.

IRONWOOD TREE
Mesua ferrea
F: Calophyllaceae

This Asian tree yields heavy timber, hence its common name. It has large flowers with four white petals and bright red young leaves.

PERFORATE ST JOHN'S-WORT
Hypericum perforatum
F: Hypericaceae

This Eurasian perennial is a common plant of banks, fields, and roadsides. It has round stems with ridges on either side, leaves with translucent dots, and many-seeded capsules.

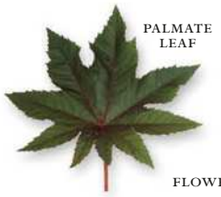
»

CANDLE-NUT TREE
Aleurites moluccanus
F: Euphorbiaceae
Oil from the nuts of this tropical tree was burnt in lamps. It has stems of small, creamy flowers and its variable leaves are grey-green when young.

CASSAVA
Manihot esculenta
F: Euphorbiaceae
The tuberous roots of this S. American plant are boiled and ground as food. It has small flower clusters that grow on secondary branches.

CROWN OF THORNS
Euphorbia milii
F: Euphorbiaceae
This semi-succulent, climbing shrub from Madagascar has very spiny stems. Its leaves are mainly on the new shoots.

BASEBALL PLANT
Euphorbia obesa
F: Euphorbiaceae
Rare in the wild, this ball-shaped succulent originates from the Great Karoo, South Africa. Its tiny flowers grow from "eyes" at its top.



CASTOR OIL PLANT
Ricinus communis
F: Euphorbiaceae
Castor oil is extracted from the poisonous seeds of this species from tropical Africa. With upright flowerheads, the upper female flowers have red stigmas and lower males yellow anthers.

JATROPHA GOSSYPIIFOLIA
F: Euphorbiaceae
This invasive, toxic plant, banned in parts of Australia, is native to tropical America. It has sticky leaves, watery sap, and flowers with purple bracts.

CROTON
Croton tiglium
F: Euphorbiaceae
Used in Chinese medicine, this tree from S.E. Asia has malodorous leaves and produces fruit capsules containing three poisonous seeds.

RUBBER TREE
Hevea brasiliensis
F: Euphorbiaceae
A native of Brazil, this tree is famous for the milky sap (latex) under its bark used for rubber. It has leaves with three leaflets and pungent yellow flowers.

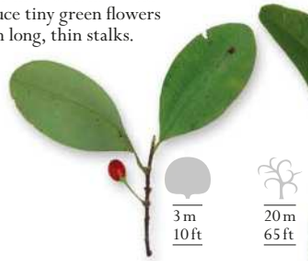
DOG'S MERCURY
Mercurialis perennis
F: Euphorbiaceae
This downy perennial has a single upright stem. Plants are either male or female and produce tiny green flowers on long, thin stalks.

PETTY SPURGE
Euphorbia peplus
F: Euphorbiaceae
This poisonous, weedy annual, native to Europe, N. Africa, and W. Asia, has dividing stems and flower stalks with three branches.

SAUSAGE SPURGE
Euphorbia quentheri
F: Euphorbiaceae
This evergreen succulent from Kenya has white flower bracts with purple markings. It has fleshy, sickle-shaped leaves mainly on young growth.

LARGE MEDITERRANEAN SPURGE
Euphorbia characias
F: Euphorbiaceae
This ornamental, Mediterranean perennial has upright, purplish, woolly stems, bare and smooth at the base. The fruit, or seed capsule, is hairy and berry-like.

PERENNIAL FLAX
Linum perenne
F: Linaceae
This slender, often spreading perennial is native from C. Europe to China. Its flowers form buds at intervals at the top of the stem.



COCA
Erythroxylum coca
F: Erythroxylaceae
The leaves of this evergreen shrub from north-western S. America yield cocaine. It has oval leaves and clusters of small, yellowish white flowers.

BLUE PASSION FLOWER
Passiflora caerulea
F: Passifloraceae
This ornamental S. American vine has scented flowers associated with Christian symbolism. Flowers have ten very similar sepals and petals, five stamens, and three purple stigmas.

10 m
33 ft

AYAHUASCA
Banisteriopsis caapi
F: Malpighiaceae

This woody vine, native to the Amazon, is traditionally used to make a sacred, medicinal drink. It produces stalks of pink flowers and winged seed pods.

25 m
80 ft

RED MANGROVE
Rhizophora mangle
F: Rhizophoraceae

Found throughout the tropics, especially in swampy salt marshes, the red mangrove has prop roots and its seeds germinate before leaving their parent tree.

RAFFLESIA
Rafflesia arnoldii
F: Rafflesiaceae

This leafless parasite on S.E Asian rainforest vines has the world's largest flowers, up to 1 m (3¼ ft) in diameter. Their foul smell attracts flies.

60 cm
23½ in

12 m
40 ft

PUSSY WILLOW
Salix caprea
F: Salicaceae

This shrubby tree, native to Europe and Asia, has downy, oval, toothed, alternate leaves. Female catkins form capsules, releasing cottony seeds.

25 m
80 ft

WHITE WILLOW
Salix alba
F: Salicaceae

This waterside tree is native to Europe and Asia. Trees have either male or female catkins, never both. The bark is a source of salicin, the active ingredient of aspirin.

21 m
70 ft

IDESIA
Idesia polycarpa
F: Salicaceae

A mountain tree from E. Asia, this has smooth grey bark. Small yellow-green, fragrant flowers produce deep red berries.

25 m
80 ft

ASPEN
Populus tremula
F: Salicaceae

Native to Europe and Asia, the grey bark of young trees has diamond-shaped scars. Flattened stalks cause the leaves of aspen to quiver.

30 m
100 ft

WHITE POPLAR
Populus alba
F: Salicaceae

This deciduous tree, native to C. Europe and C. Asia, tolerates salt water. It is unisexual, and most trees are female. Catkins form capsules that release fluffy seeds.

flower is up to 12 cm (5 in) across

fragrant flower, may be white, red, or purple

GIANT GRANADILLA
Passiflora quadrangularis
F: Passifloraceae

This passion flower is a perennial native of S. America. It bears oblong fruits on four-sided stems.

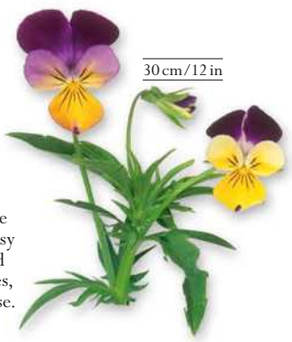
15 m
50 ft

10 m
33 ft

AZARA MICROPHYLLA
F: Salicaceae

This evergreen tree from Argentina and Chile has small, vanilla-scented flowers with yellow stamens. Each leaf has a circular growth (stipule) at the base.

30 cm/12 in



WILD PANSY
Viola tricolor
F: Violaceae

This sprawling, short-lived perennial is native to Europe and W. Asia, growing in grassy habitats with neutral to acid soils. Used in herbal remedies, it is also known as heart's-ease.

1.2 m/4 ft

SHRUB VIOLET
Pigea floribundus
F: Violaceae

This Australian woody perennial accumulates nickel. Shrub violet has bluish petals with a yellow patch and small, dark green, lance-shaped leaves.

OXALIDALES

This order contains about 2,000 species, grouped within seven families. Of these, the Cephalotaceae contains only one species – the carnivorous Albany pitcher plant. The Cunoniaceae are woody plants that produce woody fruit capsules containing small seeds. The wood sorrel family (Oxalidaceae), is the largest with 800 species within five genera. They are characterized by divided leaves that exhibit or open out by day and then close up at night.

ALBANY PITCHER PLANT
Cephalotus follicularis
F: Cephalotaceae

This carnivorous plant is native to the coast of S.W. Australia. It has basal, oval leaves, and a liquid-filled pitcher that traps prey but it is not a member of the pitcher family (see p.194).

20 cm
8 in

4 m
13 ft

CHRISTMAS BUSH
Ceratopetalum gummiferum
F: Cunoniaceae

From coastal E. Australia, this shrub produces insignificant white flowers in spring. The pink and red sepals enlarge in winter, enclosing the fruit.

PINK SORREL
Oxalis articulata
F: Oxalidaceae

Growing from a swollen rhizome, or root stalk, this plant from S. America forms leafy mounds topped with clusters of flowers. These produce seed capsules that explode.

12 m
40 ft

BLACK WATTLE
Callicoma serratifolia
F: Cunoniaceae

The wood of this shrubby tree from the east coast of Australia was used by early settlers to make wattle-and-daub shelters. Its young foliage is bronze.

STAR FRUIT
Averrhoa carambola
F: Oxalidaceae

This bushy tree, native to S.E. Asia, is widely cultivated for its edible star-shaped fruits. It can flower four times a year.

15 m/50 ft

ROSALES

This order of plants contains nine families, among them the Rosaceae (rose family), Cannabaceae (hemp family), Moraceae (mulberry family), Rhamnaceae (buckthorn family), Ulmaceae (elm family), and Urticaceae (nettle family). Members of the Rosales are often grown for their fruits or other products. Plants in this order tend to have five sepals and numerous stamens. Mostly insect-pollinated, they are often thorny or hairy.

10 m
33 ft

SEA BUCKTHORN
Hippophae rhamnoides
F: Elaeagnaceae

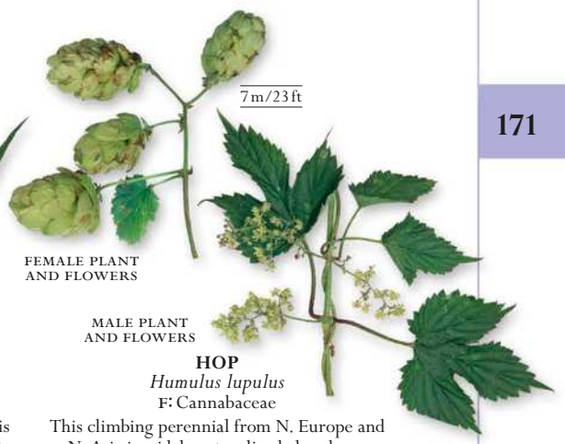
Widespread through Asia and Europe, this shrub bears tiny flowers before the leaves. The small, bright-orange berries are rich in vitamin C.

OLEASTER
Elaeagnus angustifolia
F: Elaeagnaceae

Native to Eurasia, this spreading, deciduous tree has spiny shoots, covered in silver scales. Its egg-shaped, yellow-red fruits are edible.

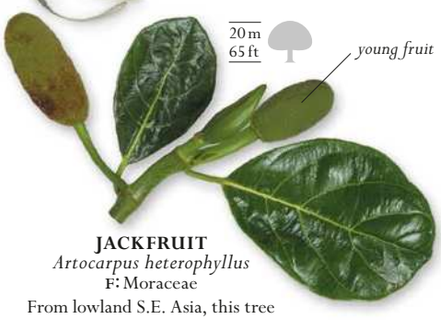
HEMP
Cannabis sativa
F: Cannabaceae

Originating from C. and W. Asia, this annual is a source of cannabis from its leaves, fibre for making rope, and oil is extracted from its seeds.



HOP
Humulus lupulus
F: Cannabaceae

This climbing perennial from N. Europe and N. Asia is widely naturalized elsewhere. The cone-like female flower or hop is used to flavour and preserve beer.

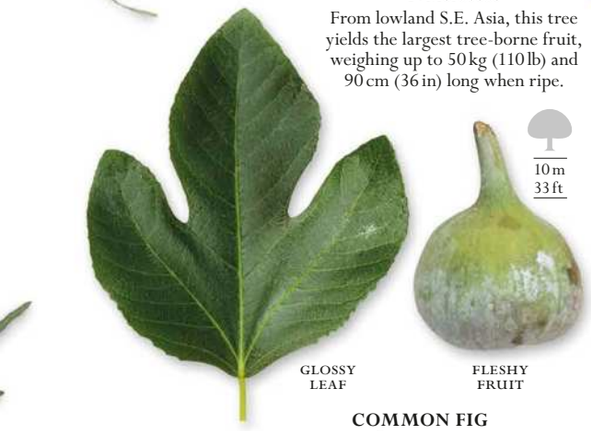


JACKFRUIT
Artocarpus heterophyllus
F: Moraceae

From lowland S.E. Asia, this tree yields the largest tree-borne fruit, weighing up to 50 kg (110 lb) and 90 cm (36 in) long when ripe.

BLACK MULBERRY
Morus nigra
F: Moraceae

This deciduous, spreading tree, widely cultivated for its rich-flavoured fruits, is native to the Middle East. It has bumpy, fissured orange bark.



COMMON FIG
Ficus carica
F: Moraceae

As with most figs, flowers of this Mediterranean and Asian species develop inside a flask-shaped receptacle and are pollinated by a single species of wasp.

SACRED FIG
Ficus religiosa
F: Moraceae

Under this sacred tree, Buddha is said to have gained enlightenment. Native to S.E. Asia, its flowers, then its fruits, are enclosed within purple, flecked figs.

PAPER MULBERRY
Broussonetia papyrifera
F: Moraceae

Fine paper is made from the inner bark of this tree from Japan and S.E. China. Male catkins produce large quantities of wind-dispersed pollen.

OSAGE ORANGE
Maclura pomifera
F: Moraceae

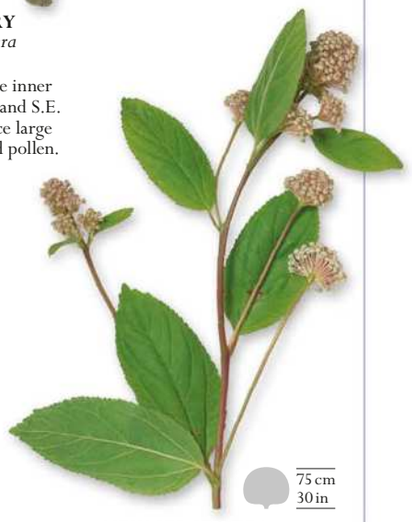
Native to S.E. USA, this tree is used for hedging and its roots and wood were valued by native Americans.

JUJUBE
Ziziphus jujuba
F: Rhamnaceae

This thorny, shrubby tree is widely cultivated for its fruits in China and Korea. The immature, smooth, oval, green stoned fruit tastes like apple.

COMMON BUCKTHORN
Rhamnus cathartica
F: Rhamnaceae

A shrubby, invasive tree that has spine-tipped shoots, tiny yellow-green flowers, and black berries. It is native to Europe, Asia, and N.W. Africa.



NEW JERSEY TEA
Ceanothus americanus
F: Rhamnaceae

This bush from eastern N. America has purple, three-lobed capsules, containing seeds. Its red roots and hairy leaves have been used to make tea.

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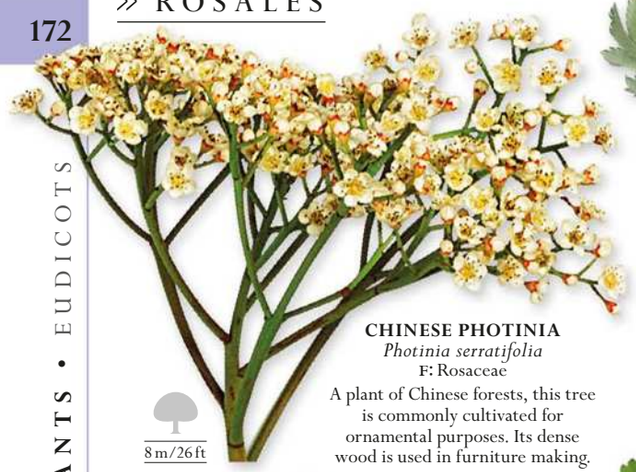


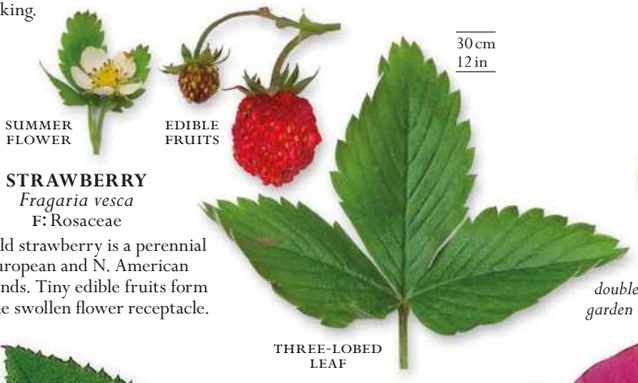
CHINESE PHOTINIA
Photinia serratifolia
F: Rosaceae
A plant of Chinese forests, this tree is commonly cultivated for ornamental purposes. Its dense wood is used in furniture making.

SILVERWEED
Potentilla anserina
F: Rosaceae
This silky-haired, creeping perennial grows in wasteland, pastures, and dunes in Europe, Asia, and N. America, and has been widely introduced elsewhere.

SNOWY MESPILUS
Amelanchier lamarckii
F: Rosaceae
Frothy clusters of star-shaped flowers in spring are followed by dark red berries in summer in this showy tree from eastern N. America.

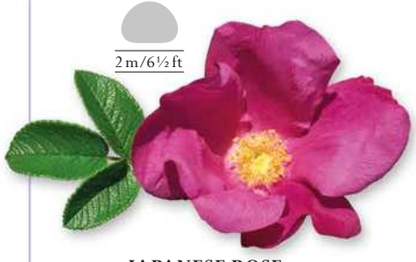
WILD CHERRY
Prunus avium
F: Rosaceae
The wild ancestor of orchard cherries grows in woods and hedges in Europe, Asia, and N. Africa and is naturalized in N. America.

PRAIRIE CRAB APPLE
Malus ioensis
F: Rosaceae
One of several crab apples native to N. America, this species is cultivated for its rather tart fruits.



STRAWBERRY
Fragaria vesca
F: Rosaceae
The wild strawberry is a perennial in European and N. American woodlands. Tiny edible fruits form from the swollen flower receptacle.

ORCHARD PLUM
Prunus domestica
F: Rosaceae
These trees originated as a cross between the cherry plum of China and the European blackthorn, but without the sharp thorns of the latter.

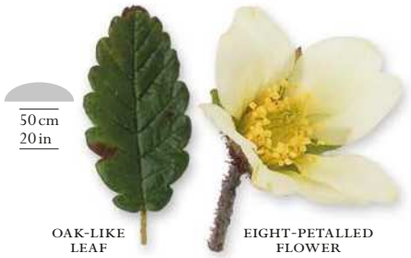


JAPANESE ROSE
Rosa rugosa
F: Rosaceae
Tolerant of salt spray, this rose from E. Asia is often planted as a hedge near the sea. It has prickly stems and pink flowers with wrinkled petals.

APOTHECARY'S ROSE
Rosa gallica var. *officinalis*
F: Rosaceae
A popular garden plant, this European parent of many floribunda and hybrid tea roses has a long pedigree. "Attar of roses" is a fragrant oil distilled from its petals.

DOG ROSE
Rosa canina
F: Rosaceae
The thorny, arching branches of this rose are familiar in hedgerows in Europe, Asia, and N. Africa. This plant is also naturalized in N. America.

SWEET BRIAR
Rosa rubiginosa
F: Rosaceae
One of the most deeply coloured wild roses, sweet briar enlivens hedgerows and scrub around Europe, Asia, and Africa. Glands on its leaves produce an apple scent when crushed.



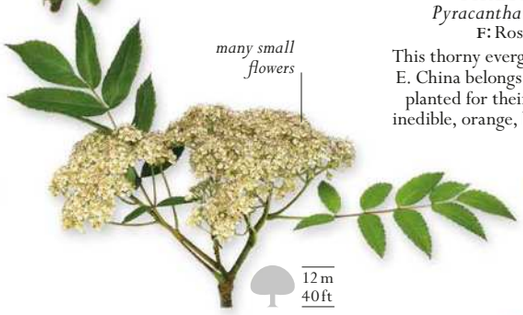
MOUNTAIN AVENS
Dryas octopetala
F: Rosaceae
The flowers of this Arctic and mountain undershrub turn to follow the sun to warm their centres and attract pollinating insects.

COTONEASTER
Cotoneaster horizontalis
F: Rosaceae
This creeping Chinese shrub is commonly grown in gardens for its flowers and fruits, and occasionally escapes. The semi-evergreen leaves form flattened clumps.

FIRETHORN
Pyracantha rogersiana
F: Rosaceae
This thorny evergreen shrub from E. China belongs to a genus often planted for their attractive but inedible, orange, berry-like fruits.

BLACKBERRY
Rubus fruticosus
F: Rosaceae
Familiar in Europe as scrambling hedgerow bushes bearing edible fruits in autumn, blackberries form a group of very closely related "microspecies".

WILD SERVICE TREE
Sorbus torminalis
F: Rosaceae
This rare tree grows in ancient woods in Europe, Asia Minor, and N. Africa. Its name is derived from the brew, *cerevisia*, made from its fruits.

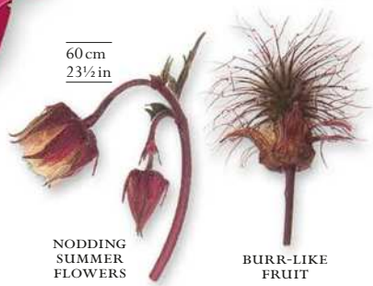


AMERICAN MOUNTAIN ASH
Sorbus americana
F: Rosaceae
This deciduous woodland tree is native to eastern N. America. Its orange berries last into winter, providing food for thrushes and jays.

MEDLAR
Mespilus germanica
F: Rosaceae
Originally from C. and S. Europe, medlar produces a hard, yellowish brown fruit. This turns soft and edible in autumn, then decays.

WILLOW-LEAVED PEAR
Pyrus salicifolia
F: Rosaceae
Cultivated for its pendulous, silvery foliage, not its inedible fruits, this Middle Eastern tree is endangered in the wild in Turkey.

SALAD BURNET
Sanguisorba minor
F: Rosaceae
Native from Europe to Iran, and introduced in N. America, this perennial of lime-rich grassland has edible leaves, hence its name.



WATER AVENS
Geum rivale
F: Rosaceae
This downy perennial grows in damp places in Europe, Asia Minor, and N. America. Hooked hairs on the fruits latch onto animals for dispersal.

LADY'S MANTLE
Alchemilla vulgaris
F: Rosaceae
This name encompasses several closely related grassland species from Europe, Asia, and eastern N. America. Their leaves are said to resemble a trailing gown.

COMMON HAWTHORN
Crataegus monogyna
F: Rosaceae
Occurring in woods and hedges in the wild from Europe and N. Africa to Afghanistan, this densely branched small tree produces massed white blossom in spring, followed by deep red fruits. It is also cultivated in gardens.

SWEET BRIAR
Rosa rubiginosa

Sweet briar, or eglantine rose, is one of the most attractive of a range of wild roses that brighten hedgerows and scrub across Europe into Asia and Africa. They have five-petalled flowers that are usually white or pale pink. To non-botanists, they seem rather similar, and are often called "dog roses". This derogatory name is said to be because they are less showy and strongly scented than the garden roses bred by horticulturalists over centuries, although some would argue they have a more subtle beauty and delicate scent than their fancy relatives. Many are prickly shrubs with scrambling, arched stems, for which "briar" is a descriptive term. Sweet briar has deep pink flowers and leaves that emit the scent of apples when crushed. It has been introduced to the Americas and Australia, where it has become invasive.

prickly, spreading stem

SIZE Erect stems to 2 m (6½ ft) tall
HABITAT Open scrub, hedgerows, parks, and roadsides
DISTRIBUTION Europe to Asia, introduced elsewhere

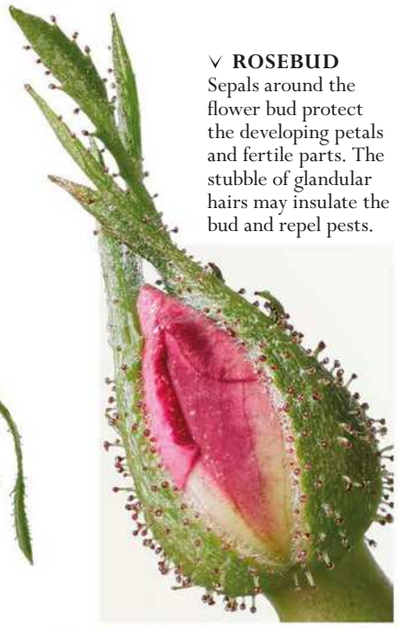
leaflet teeth fringed with stalked glands

leaflet with saw-toothed edge

∨ DEVELOPING HIPS
The flower base swells to form a succulent hip, technically a "false fruit" because it is not formed from the ovary. This contains numerous, small, one-seeded "pips" which are the true fruits.

sepals remain as a leafy tuft

∨ ROSEBUD
Sepals around the flower bud protect the developing petals and fertile parts. The stubble of glandular hairs may insulate the bud and repel pests.

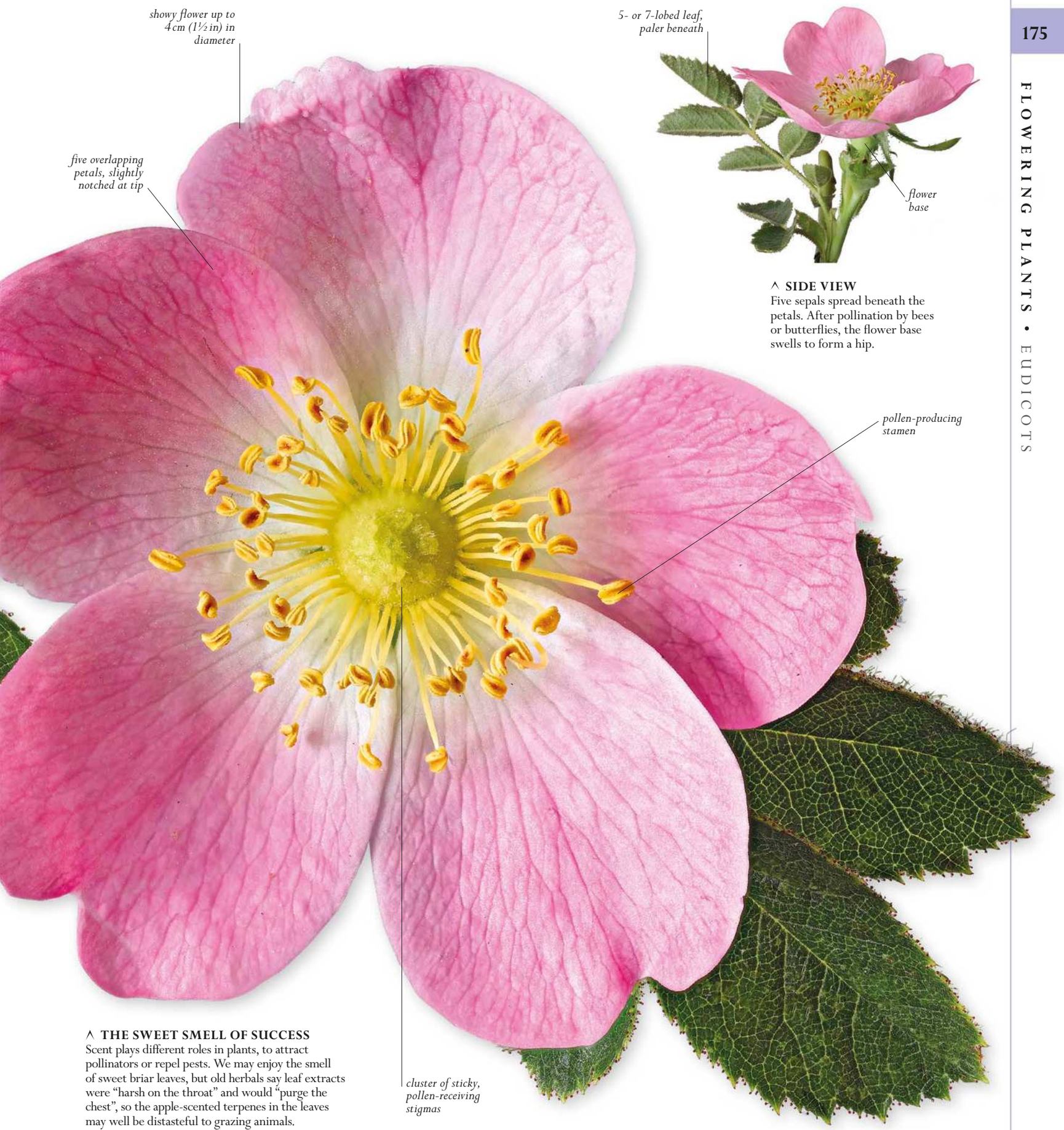


∨ UNDERSIDE OF LEAF
The under surface of the leaf is densely hairy, mixed with many brownish, stalked glands. These release sweet-smelling terpene chemicals that may deter grazers.

STAMENS >
Numerous stamens cluster in whorls around the centre of the sweet briar flower. They have pale stalks and bright yellow anthers, which produce copious amounts of pollen.

THORNS >
Hooked thorns, interspersed with strong bristles, discourage large animals from grazing the leaves.

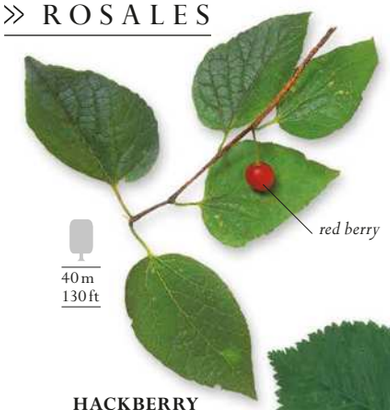
< RIPE HIPS
Hips shed their sepal tuft before ripening. Ripe, red hips are rich in vitamin C and are eaten by thrushes and pigeons, which spread the seeds in their droppings.


showy flower up to 4 cm (1½ in) in diameter
five overlapping petals, slightly notched at tip
pollen-producing stamen
cluster of sticky, pollen-receiving stigmas
5- or 7-lobed leaf, paler beneath
flower base

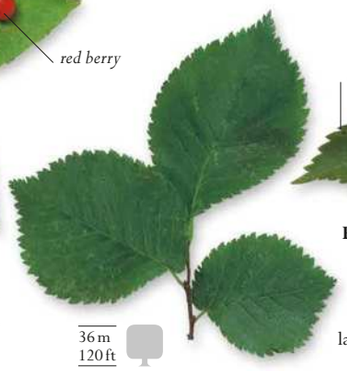
^ SIDE VIEW
Five sepals spread beneath the petals. After pollination by bees or butterflies, the flower base swells to form a hip.

^ THE SWEET SMELL OF SUCCESS
Scent plays different roles in plants, to attract pollinators or repel pests. We may enjoy the smell of sweet briar leaves, but old herbals say leaf extracts were "harsh on the throat" and would "purge the chest", so the apple-scented terpenes in the leaves may well be distasteful to grazing animals.

» ROSALES



HACKBERRY
Celtis occidentalis
F: Cannabaceae
Native to N. America, hackberry has bright green, elm-like leaves, and red fruits eaten by many birds and mammals.



JAPANESE ZELKOVA
Zelkova serrata
F: Ulmaceae
In the USA elms killed by Dutch Elm Disease are sometimes replaced by this valuable Asian timber tree. The Japanese grow it in bonsai form.

EUROPEAN FIELD ELM
Ulmus minor
F: Ulmaceae
This tree used to be a major feature in European landscapes, but was decimated by Dutch Elm Disease.

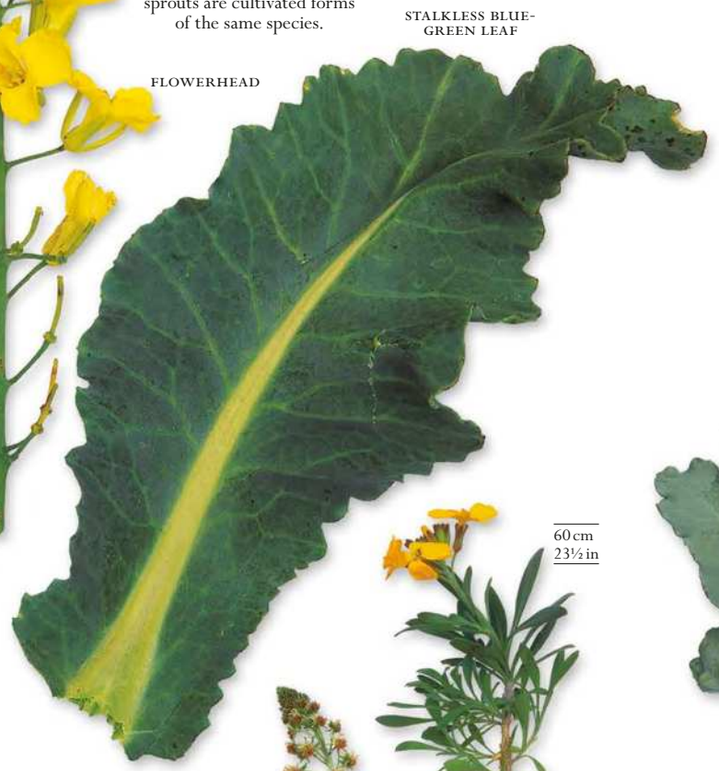
FRIENDSHIP PLANT
Pilea involucrata
F: Urticaceae
Several *Pilea* species make valuable houseplants, including this species from C. and S. America with strongly veined leaves.

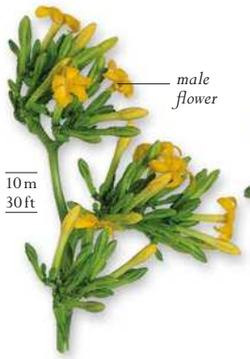
STINGING NETTLE
Urtica dioica
F: Urticaceae
Stinging hairs discourage animals from eating nettle leaves. This species grows in disturbed ground in Europe, Asia, N. Africa, and N. America.

BRASSICALES

The order Brassicales has 17 families. Many members have bitter or fragrant oils in their leaves, stems, or swollen roots. Although these oils evolved to deter grazers, they make many species pleasantly edible for humans, and have culinary, perfumery, or herbal uses. The cabbage family (Brassicaceae), is the largest group, with 3,300 species.

WILD CABBAGE
Brassica oleracea
F: Brassicaceae
Humans have grown this W. European plant for millennia. Cauliflower, broccoli, and brussels sprouts are cultivated forms of the same species.

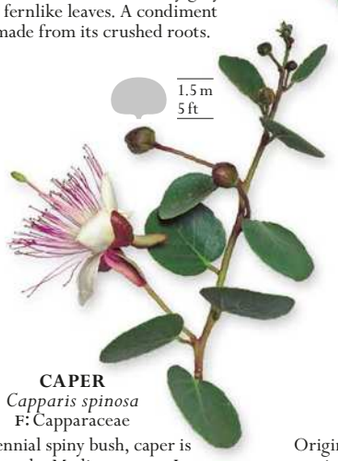




PAPAYA
Carica papaya
F: Caricaceae
This C. and S. American tree-like plant produces yellow flowers. The female flowers develop into large orange-fleshed fruits of the same name.

HORSERADISH TREE
Moringa oleifera
F: Moringaceae
This tropical Asian tree has corky grey bark and fernlike leaves. A condiment can be made from its crushed roots.

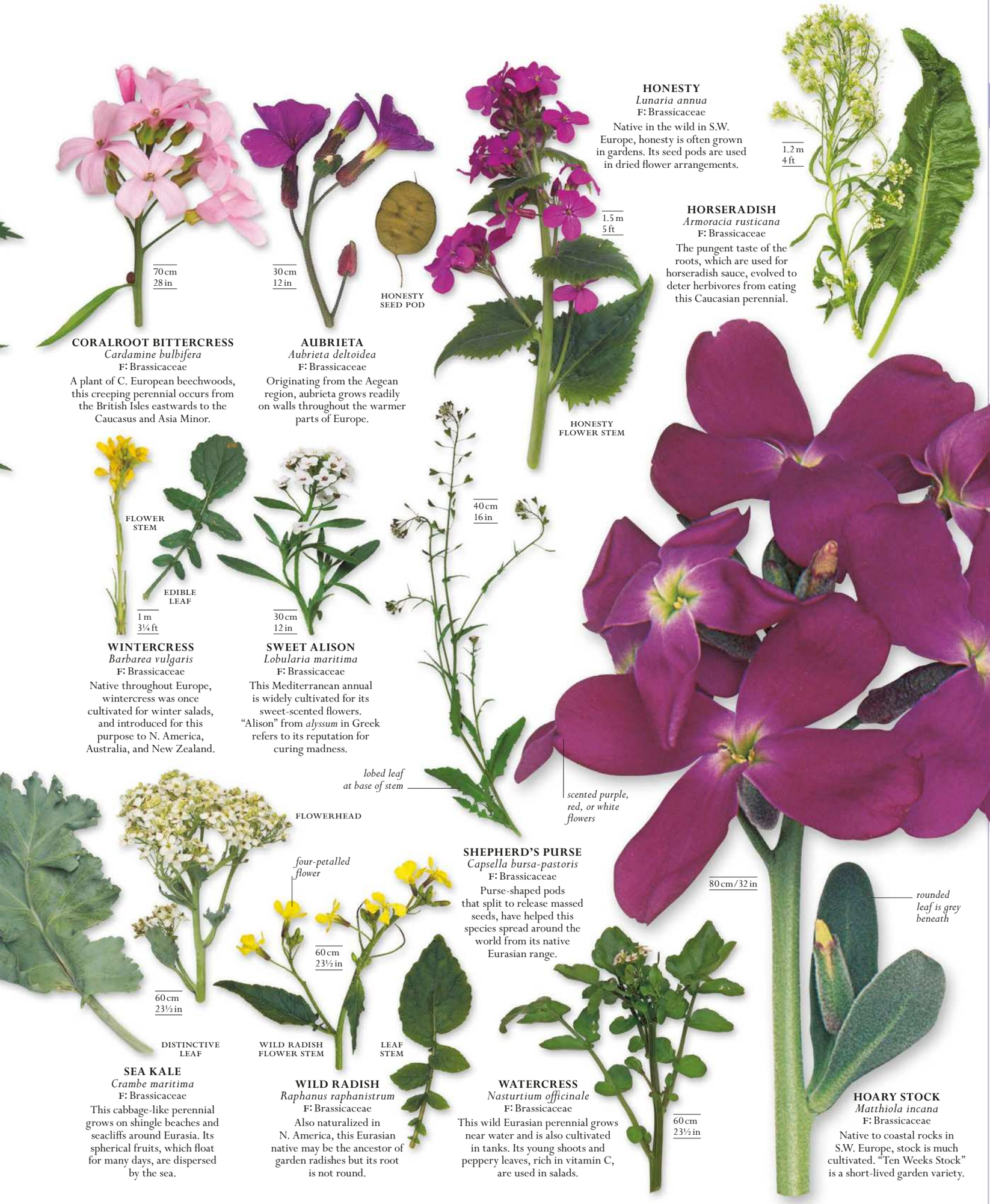
NASTURTIUM
Tropaeolum majus
F: Tropaeolaceae
A colourful annual from C. and S. America, this is a popular garden plant. The flowers and leaves can be eaten in salads.



CAPER
Capparis spinosa
F: Capparaceae
A perennial spiny bush, caper is native to the Mediterranean. Its flower buds are used salted and pickled for culinary use.

COMMON MIGNONETTE
Reseda odorata
F: Resedaceae
Originally from N. Africa, common mignonette is grown in gardens across S. Europe. An oil from its fragrant flowers is used in perfumery.

WALLFLOWER
Erysimum x *cheiri*
F: Brassicaceae
Probably first developed as a hybrid in Greece, this species has been cultivated throughout Europe since medieval times.



HONESTY
Lunaria annua
F: Brassicaceae

Native in the wild in S.W. Europe, honesty is often grown in gardens. Its seed pods are used in dried flower arrangements.

HORSERADISH
Armoracia rusticana
F: Brassicaceae

The pungent taste of the roots, which are used for horseradish sauce, evolved to deter herbivores from eating this Caucasian perennial.

CORALROOT BITTERCRESS
Cardamine bulbifera
F: Brassicaceae

A plant of C. European beechwoods, this creeping perennial occurs from the British Isles eastwards to the Caucasus and Asia Minor.

AUBRIETA
Aubrieta deltoidea
F: Brassicaceae

Originating from the Aegean region, aubrieta grows readily on walls throughout the warmer parts of Europe.

WINTERCRESS
Barbarea vulgaris
F: Brassicaceae

Native throughout Europe, wintercress was once cultivated for winter salads, and introduced for this purpose to N. America, Australia, and New Zealand.

SWEET ALISON
Lobularia maritima
F: Brassicaceae

This Mediterranean annual is widely cultivated for its sweet-scented flowers. "Alison" from *alyssum* in Greek refers to its reputation for curing madness.

SHEPHERD'S PURSE
Capsella bursa-pastoris
F: Brassicaceae

Purse-shaped pods that split to release massed seeds, have helped this species spread around the world from its native Eurasian range.

SEA KALE
Crambe maritima
F: Brassicaceae

This cabbage-like perennial grows on shingle beaches and seacliffs around Eurasia. Its spherical fruits, which float for many days, are dispersed by the sea.

WILD RADISH
Raphanus raphanistrum
F: Brassicaceae

Also naturalized in N. America, this Eurasian native may be the ancestor of garden radishes but its root is not round.

WATERCRESS
Nasturtium officinale
F: Brassicaceae

This wild Eurasian perennial grows near water and is also cultivated in tanks. Its young shoots and peppery leaves, rich in vitamin C, are used in salads.

HOARY STOCK
Matthiola incana
F: Brassicaceae

Native to coastal rocks in S.W. Europe, stock is much cultivated. "Ten Weeks Stock" is a short-lived garden variety.

MALVALES

The ten families in the Malvales include many shrubs and trees, found mainly in tropical and warm temperate regions, but extending into cooler parts. The main members are the rockrose family (Cistaceae), mostly shrubs from the northern hemisphere; the more widespread mallow family (Malvaceae) of herbs, shrubs, and massive trees; and the pantropical Dipterocarpaceae, which includes some of the most important tropical timber trees.

COMMON ROCKROSE
Helianthemum nummularium
F: Cistaceae

Found on sunny banks throughout most of Europe, this low shrub prefers lime-rich soils. Different subspecies grow in Europe's mountains.

HAIRY ROCKROSE
Cistus incanus
F: Cistaceae

Several scientific names have been given to this widespread Mediterranean shrub, because its leaves vary greatly in hairiness and size.

ANNATTO
Bixa orellana
F: Bixaceae

The food dye annatto comes from the spiny fruits of this pink-flowered shrub or small tree, native to tropical America.

CALIFORNIAN FLANNELBUSH
Fremontodendron californicum
F: Malvaceae

The flowers of this spreading shrub produce showy masses in early summer. It lives high up in the granite mountains of California.

CHINESE HIBISCUS
Hibiscus rosa-sinensis
F: Malvaceae

Possibly native to India, despite its name, this tropical shrub is one of several *Hibiscus* species cultivated for their showy blossoms.

COCOA
Theobroma cacao
F: Malvaceae

Originally from Brazilian rainforests, this tree is cultivated around the tropics. Cocoa comes from the seeds, known as beans, inside its fruit pods.

MEZEREON
Daphne mezereum
F: Thymelaeaceae

Damp woods and shady gorges are the typical habitat of this deciduous shrub, which is found across most of Europe.

MUSK MALLOW
Malva moschata
F: Malvaceae

Native to N. Africa and S. Europe, and a garden plant further north, this tall perennial grows in grassy and bushy places.

COLA NUT TREE
Cola nitida
F: Malvaceae

The caffeine-rich seeds (called cola nuts) from the pods of this W. African tree are chewed for their stimulant effects.

BAOBAB TREE
Adansonia digitata
F: Malvaceae

This massive African tree is called an upside-down tree because, when leafless, its branches look like roots. It can live for 1,500 years.

TRAILING ABUTILON
Callianthe megapotamicum
F: Malvaceae

Native to dry mountain valleys of Brazil, this spreading shrub is also popular as a colourful ornamental in warm, sunny gardens.

1.8 m
6 ft

GLOSSY LEAVES

SPINY FRUIT

40 m
130 ft

DURIAN
Durio zibethinus
F: Malvaceae

The spiny fruits of this Asian rainforest tree smell of sweaty socks. This attracts animals to eat the fruit then disperse the seeds in their droppings.

36 m
120 ft

1.8 m
6 ft

AMERICAN LIME
Tilia americana
F: Malvaceae

This medium to large deciduous tree adds to autumn colours in woodlands across eastern N. America. It often grows alongside sugar maple.

FLOWER SPRIG

PALMATE LEAVES

70 m
230 ft

OPEN BOLL

1.5 m
5 ft

WILD HOLLYHOCK
Alcea pallida
F: Malvaceae

This tall evergreen perennial, a close relative of garden hollyhocks, comes from the E. Mediterranean. It grows in rocky places and scrubland.

DOWN-FILLED POD

KAPOK
Ceiba pentandra
F: Malvaceae

Massive kapok trees grow wild in W. Africa, and C. and S. America. Fibre from their fruits, or pods, is used as a stuffing for toys.

UPLAND COTTON
Gossypium hirsutum
F: Malvaceae

This C. American shrub is the most common cultivated cotton species. The cotton fibres protect seeds inside the fruit, or boll.

SAPINDALES

The Sapindales is an important order of nine families, mostly of trees, shrubs, and woody vines, often with divided leaves. It includes many dominant woodland species and commercially important species such as citrus fruits. More than half its members belong to two families: the maple family (Sapindaceae), with around 1,900 species; and the rue family (Rutaceae), with 1,700 species, which mostly originate in Australia and South Africa.

EVERGREEN LEAVES

40 m/130 ft

5 m/16 ft

RIPE FRUIT

12 m/40 ft

CASHEW
Anacardium occidentale
F: Anacardiaceae

Originally from S. America, this shrubby tree was taken to Asia and Africa in the 1500s, and cultivated for its nuts.

10 m/33 ft

STAG'S HORN SUMACH
Rhus typhina
F: Anacardiaceae

This deciduous shrub or small tree grows on forest edges and wasteland in eastern N. America. It has spiky clusters of red berries.

SMOKE BUSH
Cotinus coggygria
F: Anacardiaceae

Finely branched clusters of pale green flowers give this bush a smoky appearance. It is found in S. Europe and Asia.

MANGO
Mangifera indica
F: Anacardiaceae

A native of Asia, mango is one of the most widely cultivated fruits in the tropical world, and is rich in vitamin A.

»

» SAPINDALES

CRABWOOD
Carapa guianensis
F: Meliaceae

The dark timber of this tropical S. American tree is sometimes sold as Brazilian mahogany. Soap is made from its seeds.

NEEM TREE
Azadirachta indica
F: Meliaceae

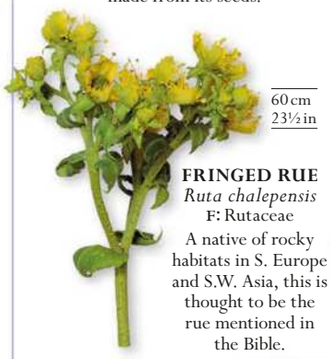
Valued for its timber, medicinal oils, and edible shoots, this tree is grown throughout the Old World tropics. Indian farmers produce insecticides from the oil and leaves.

CHINESE MAHOGANY
Toona sinensis
F: Meliaceae

Chinese people eat the leaves of this E. Asian tree as a vegetable. Furniture is made from its hard, reddish timber.

SCENTED BORONIA
Boronia megastigma
F: Rutaceae

This erect shrub of wet sandy sites in W. Australia has bell-like flowers, brownish on the outside and golden-green inside.



FRINGED RUE
Ruta chalepensis
F: Rutaceae

A native of rocky habitats in S. Europe and S.W. Asia, this is thought to be the rue mentioned in the Bible.

PEPPER AND SALT
Philoteca spicata
F: Rutaceae

Widespread in sandy and gravelly places in S.W. Australia, this low shrub has narrow leaves and pink, white, or bluish flowers.

SYDNEY ROCKROSE
Boronia serrulata
F: Rutaceae

This small shrub, in a genus confined to Australia, grows in coastal heaths near Sydney. It has bright pink, cup-shaped flowers.

MEXICAN ORANGE
Choisya ternata
F: Rutaceae

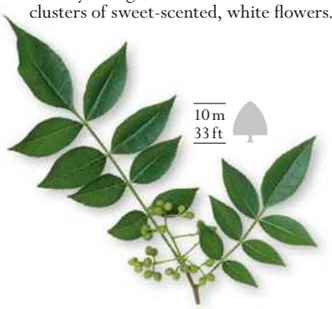
Originating from Mexico but common in gardens elsewhere, this irregular, bushy, evergreen shrub has branched clusters of sweet-scented, white flowers.

HOP TREE
Ptelea trifoliata
F: Rutaceae

This small tree, native to eastern N. America, is grown for ornament. Its fruits were once used as a substitute for hops in brewing.

SALMON CORREA
Correa pulchella
F: Rutaceae

A native of South Australia, this small shrub is grown in gardens for its delicate, pendulous, tubular flowers.



COMMON PRICKLY ASH
Zanthoxylum americanum
F: Rutaceae

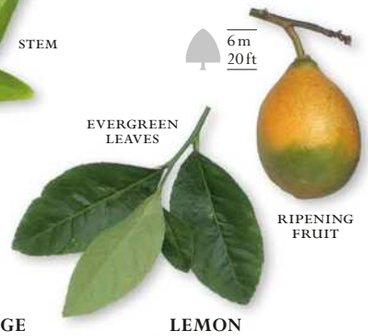
This spiny N. American tree grows as far north as Quebec, Canada. Native Americans chewed its bark to help soothe toothache.

SKIMMIA
Skimmia japonica
F: Rutaceae

Much planted in gardens, parks, and amenity areas, this evergreen, aromatic shrub from E. Asia produces red berries in late summer.

JAPANESE BITTER ORANGE
Citrus trifoliata
F: Rutaceae

The small, inedible yellow fruits of this spiny shrub resemble oranges with a downy skin. They have several medicinal uses.



LEMON
Citrus x *limon*
F: Rutaceae

Thought to have originated by hybridization in Assam or China, this evergreen tree is now widely cultivated for its fruits.

SEVILLE ORANGE
Citrus x *aurantium*
F: Rutaceae

Unlike the sweet orange we eat raw (*C.* x *sinensis*), this species' bitter fruits are only good for cooking. Both originated as Asian hybrids.

35 m
115 ft

SUGAR MAPLE
Acer saccharum
F: Sapindaceae

This tree is native to N.E. USA and S.E. Canada. Maple syrup is made by boiling the sap collected from the tree in spring.

16 m
52 ft

JAPANESE MAPLE
Acer palmatum
F: Sapindaceae

Centuries of breeding have produced many cultivated varieties of this native Japanese tree, with varying leaf shapes and spectacular autumn colours.

SYCAMORE
Acer pseudoplatanus
F: Sapindaceae

Native to mountain woods in Europe and Asia, sycamore is widely planted elsewhere. Its winged seeds spread in the wind.

30 m
100 ft

12 m
40 ft

GOLDEN-RAIN TREE
Koelreuteria paniculata
F: Sapindaceae

This showy tree from E. Asia is much planted in temperate regions for its cascading yellow blossoms and distinctive bladder-like seed pods.

8 m
26 ft

YELLOWHORN
Xanthoceras sorbifolium
F: Sapindaceae

This small tree grows wild in China. Its scientific name records its leaves, which resemble those of rowan (*Sorbus*).

30 m
100 ft

LYCHEE
Litchi chinensis
F: Sapindaceae

Probably originating in S. China, this tree is cultivated for its fruits. Their sweet flesh is encased within a tough shell.

40 m
130 ft

HORSE CHESTNUT
Aesculus hippocastanum
F: Sapindaceae

Native to S.E. Europe, this tree is often planted for shade along city streets. Its fruits resemble chestnuts but are hard and inedible.

40 m
130 ft

JAVA ALMOND
Canarium indicum
F: Burseraceae

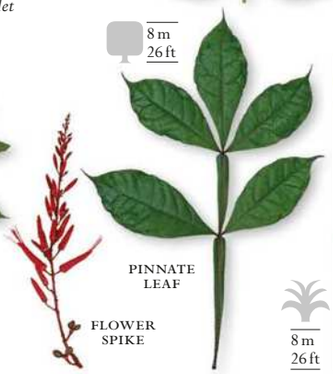
Native to rainforests in the Pacific islands, this is one of the region's most useful trees, providing timber, oil, and edible nuts.

20 m
65 ft

TREE OF HEAVEN
Ailanthus altissima
F: Simaroubaceae

Hailing from China, this slightly rank-smelling tree is planted along city streets because it endures pollution and most soil types.

8 m
26 ft



BITTERWOOD
Quassia amara
F: Simaroubaceae

Boiled extracts from the bark and leaves of this tree are used to make tonics against malaria in tropical America.

8 m
26 ft

FRANKINCENSE
Boswellia sacra
F: Burseraceae

Frankincense, a gum resin used in incense and to fix perfumes, oozes as milky juice from cuts in trunks of these Arabian trees.

CARYOPHYLLALES

The Caryophyllales is a diverse order of 38 families of trees, shrubs, climbers, succulents, and herbaceous plants, ranging from carnations to cacti. Many grow in difficult environments, but have evolved special adaptations for survival. Some have fleshy leaves to store water in drought conditions. Another extreme example is the ability of carnivorous species to trap and digest insects for extra nutrients.

CONOPHYTUM MINUTUM
F: Aizoaceae

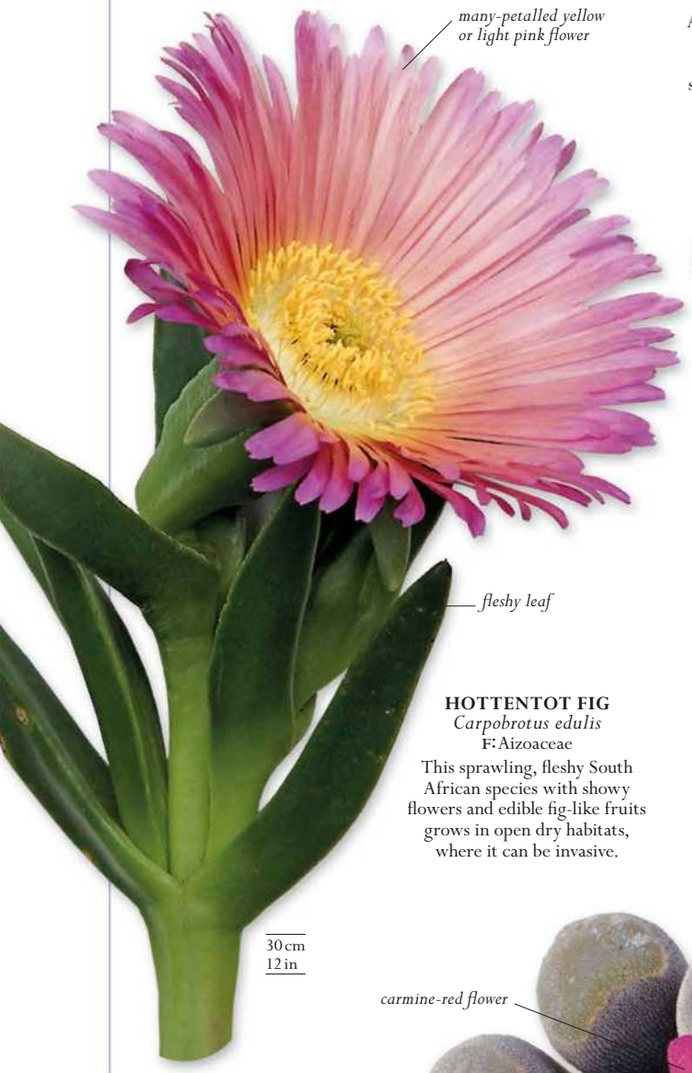
A minute, clump-forming species, with fleshy "pebble-like" leaves, this succulent perennial inhabits semi-desert areas in South Africa.

WARTY TIGER JAWS
Faucaria tuberculosa
F: Aizoaceae

Native to semi-desert areas of South Africa, this species has warty leaves that resemble an open mouth, hence the name.

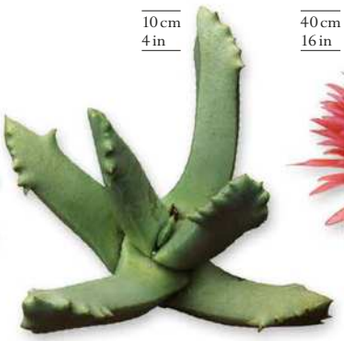
PURPLE DEWPLANT
Disphyma crassifolium
F: Aizoaceae

This procumbent species – with stems that trail along ground – has fleshy leaves and daisy-like flowers. Native to South Africa, Australia, and New Zealand, it lives on saline soils.



HOTTENTOT FIG
Carpobrotus edulis
F: Aizoaceae

This sprawling, fleshy South African species with showy flowers and edible fig-like fruits grows in open dry habitats, where it can be invasive.



SCHWANTESIA RUEDEBUSCHII
F: Aizoaceae

A clump-forming species with unequal pairs of keeled fleshy leaves, this succulent grows on hillsides in Namibia and South Africa.

LAMPRANTHUS AURANTIACUS
F: Aizoaceae

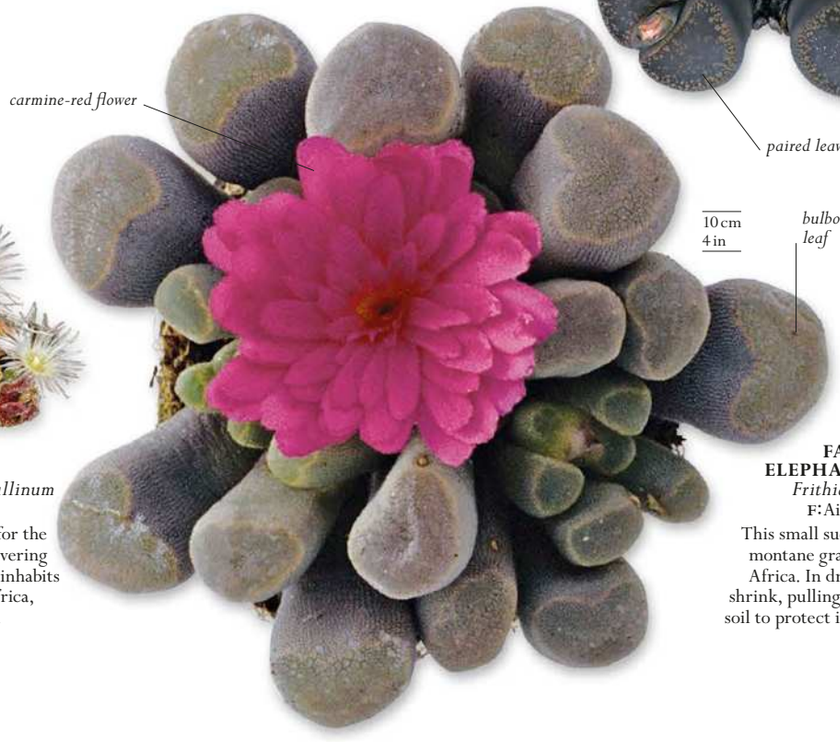
This succulent plant grows in sandflats along the west coast of South Africa, where it is known locally as "vygie". Its daisy-like flowers are about 5 cm (2 in) across.

TITANOPSIS CALCAREA
F: Aizoaceae

The encrusted leaves of this South African succulent disguise it amongst desert limestone rocks. It flowers in late summer and autumn.

LIVING STONES
Lithops aucampiae
F: Aizoaceae

Growing among pebbles in semi-desert regions of South Africa, this dwarf clump-forming species has bulbous leaves.



ICE PLANT
Mesembryanthemum crystallinum
F: Aizoaceae

Popularly named ice plant for the tiny glistening swellings covering the entire plant, this species inhabits saline areas in parts of Africa, Europe, and W. Asia.

FAIRY ELEPHANT'S FEET
Frithia pulchra
F: Aizoaceae

This small succulent grows in montane grassland in South Africa. In drought its leaves shrink, pulling the plant into the soil to protect it from desiccation.

GIBBAEUM VELUTINUM
F: Aizoaceae

Pairs of unequal-sized fleshy leaves, joined near their bases, characterize this mat-forming species. It is found in semi-desert areas in South Africa.

LOVE-LIES-BLEEDING
Amaranthus caudatus
F: Amaranthaceae
Believed to originate in S.America, this annual plant has long been cultivated for its edible leaves and seeds.

POLPALA
Aerva lanata
F: Amaranthaceae
With catkin-like flower clusters, this perennial from tropical regions of Asia and Africa grows on open, disturbed ground.

ACHYRANTHES BIDENTATA
F: Amaranthaceae
Forest edges, streamsides, and moist shady places in China, Japan, India, and Nepal are home to this species.

ANNUAL SEABLITE
Suaeda maritima
F: Amaranthaceae
Mainly coastal, inhabiting salt marshes in Europe, but growing inland in parts of Asia and N. America, annual seablite has green leaves which turn red.

SEA BEET
Beta vulgaris
F: Amaranthaceae
The wild ancestor of beetroot, sea beet is a fleshy inhabitant of bare ground by the sea in parts of Europe, N. Africa, and Asia.

SEA PURSLANE
Atriplex portulacoides
F: Amaranthaceae
Salt marshes, especially edges of tidal channels and pools, are home to sea purslane, a sprawling silvery species from S. Europe and the Mediterranean.

COMMON GLASSWORT
Salicornia europaea
F: Amaranthaceae
Common glasswort is a bushy species of muddy salt marshes in W. Europe. Its succulent stems are sometimes cooked as a vegetable.

GARDEN ORACHE
Atriplex hortensis
F: Amaranthaceae
Probably originally from seashores in S.W. Asia, this spinach-like species has long been cultivated for its edible leaves.

MEXICAN TEA
Dysphania ambrosioides
F: Amaranthaceae
A short-lived inhabitant of cultivated and waste ground in tropical America, this aromatic species is used as a seasoning and in tea.

PLUMED COCKSCOMB
Celosia argentea
F: Amaranthaceae
This showy plant is native to dry slopes and stony ground in tropical Africa, but is widely planted elsewhere for its colourful foliage.

»

PARODIA HASELBERGII
F: Cactaceae
This cactus has a spherical stem and funnel-shaped flowers. It inhabits mountainous parts of Brazil.

15 cm
6 in

spines protect slow-growing plant

ERIOSYCE SUBGIBBOSA
F: Cactaceae
This spherical species grows in dry stony places, often at the coast in its native Chile.

90 cm
35 in

funnel-shaped flower

flesh in leaf stores water

10 cm/4 in

7 m
23 ft

PERUVIAN OLD MAN CACTUS
Espostoa lanata
F: Cactaceae
Identified by long, white hairs on the columnar stem, this is a slow-growing species from hilly areas of Peru and S. Ecuador.

40 cm
16 in

BARREL CACTUS
Echinocactus sp.
F: Cactaceae
The barrel-shaped members of this genus are confined to the deserts of S.W. USA and Mexico.

60 cm/23½ in

REBUTIA HELIOSA
F: Cactaceae
A clump-forming species with brightly coloured flowers, this native of Bolivia grows in partially shaded mountainous habitats.

12 m
40 ft

OLD MAN CACTUS
Cephalocereus senilis
F: Cactaceae
Long white hairs on the stem give this cactus its common name. It is native to rocky areas in Mexico.

60 cm
23½ in

CLEISTOCACTUS BROOKEAE
F: Cactaceae
With semi-erect or spreading fleshy single stems, this species inhabits mountainous areas of Bolivia.

GOLDEN COLUMN
Weberbauerocereus johnsonii
F: Cactaceae
This is a tall species from Peru, where it inhabits sandy soils.

6 m
20 ft

16 m
52 ft

arm, or branch, supports extra flowers

LEUCHTENBERGIA PRINCIPIS
F: Cactaceae
The stem of this species is either spherical or short and cylindrical, and bears fragrant flowers. It inhabits semi-desert regions of N. Mexico.

4 m/13 ft

MISTLETOE CACTUS
Rhipsalis baccifera
F: Cactaceae
The only cactus found naturally outside the Americas, this epiphyte was perhaps carried to tropical Africa, Madagascar, and Sri Lanka by migrating birds.

SAGUARO CACTUS
Carnegiea gigantea
F: Cactaceae
Living for up to 150 years in desert areas of Mexico and Arizona, and California, USA, saguaro cactus is an extremely tall species.

2.4 m
7¾ ft

5 m
16 ft

19 m
62 ft

GIANT CARDÓN
Pachycereus pringlei
F: Cactaceae
The tallest living cactus species, giant cardón grows in the desert of Baja California, Mexico. Its flowers open at night.

QUEEN OF THE NIGHT
Harrisia jusbertii
F: Cactaceae
Possibly of natural hybrid origin in the hills of Argentina and Paraguay, this columnar cactus opens its flowers at night, hence its name.

LOPHOCEREUS SCHOTTII
F: Cactaceae
A tall slow-growing species from Mexico and S. Arizona, USA, this species has unpleasant-smelling flowers that open at night.

MATUCANA INTERTEXTA
F: Cactaceae

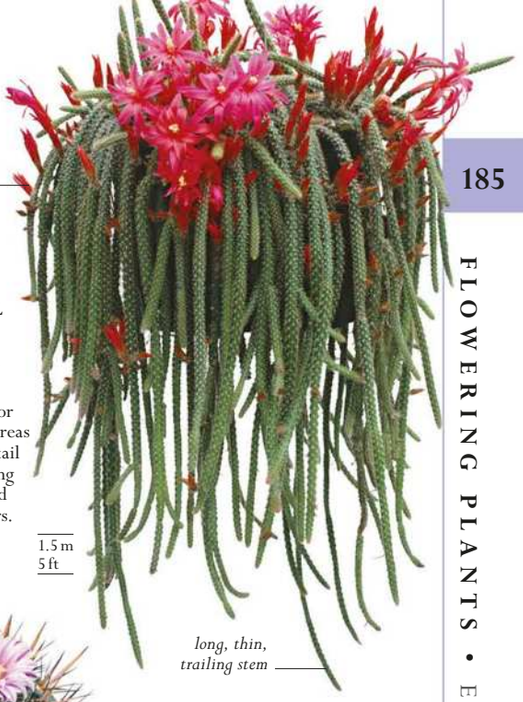
A mountain valley region of Peru is the only home of this clump-forming species with a spherical or short cylindrical stem.

MONK'S HOOD CACTUS
Astrophytum ornatum
F: Cactaceae

A spherical or columnar stem with long, brownish yellow protective spines characterizes this species. It grows in arid areas of Mexico.

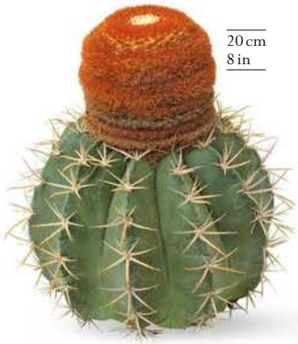
CLARET CUP HEDGEHOG
Echinocereus triglochidiatus
F: Cactaceae

Growing in deserts, scrub and on rocky slopes in S. USA and N. Mexico, this variable cactus is pollinated by hummingbirds.



RAT'S-TAIL CACTUS
Aporocactus flagelliformis
F: Cactaceae

Living on trees or rocks in wooded areas of Mexico, rat's-tail cactus has trailing fleshy stems and colourful flowers.



TURK'S CAP CACTUS
Melocactus salvadorensis
F: Cactaceae

With a characteristic flower-bearing structure on top of a spherical stem when mature, turk's cap cactus inhabits open rocky ground in N.E. Brazil.

OLD LADY CACTUS
Mammillaria hahniana
F: Cactaceae

Growing in semi-desert regions, old lady cactus is a Mexican species with greyish hairs on the spherical stem.

BRAIN CACTUS
Stenocactus multicostatus
F: Cactaceae

This spherical species inhabits dry grasslands in N.E. Mexico. Funnel-shaped buds open into pink striped flowers.

GYMNOCALYCIUM HORSTII
F: Cactaceae

This spherical, clump-forming cactus probably grows wild only in rocky grassland near Rio Grande do Sul in Brazil.

CRAB CACTUS
Schlumbergera truncata
F: Cactaceae

An epiphytic winter-flowering species of tropical rainforest in S.E. Brazil, crab cactus is often grown as a houseplant.

PRICKLY PEAR
Opuntia ficus-indica
F: Cactaceae

With flattened jointed stems and edible egg-shaped fruits, prickly pear is a native of rocky hillsides and dry ground in Mexico, and is widely naturalized elsewhere.

GLORY OF TEXAS
Thelocactus bicolor
F: Cactaceae

Native to arid regions of Texas, USA, and N.E. Mexico, this is a spherical species.

»

SPIKY HAIRY STAR
Viewed from above, this cactus appears star shaped, with five to ten (usually eight) outstretched ribs, and cross bands of woolly, white scales across the surface between them.

clusters of 5–11 spines grow from a small hollow, or areole, surrounded by white hair

MONK'S HOOD CACTUS

Astrophytum ornatum

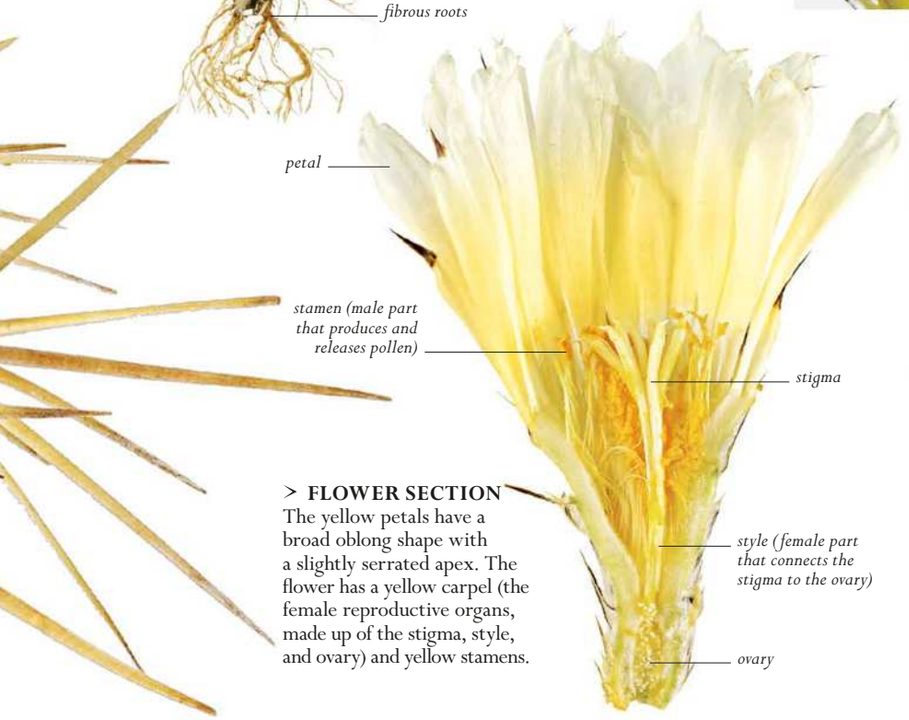
The genus name for this cactus, *Astrophytum*, means "star plant" in ancient Greek. It was first collected in 1827 by Thomas Coulter, an Irish doctor and botanist, who sent it to Professor de Candolle at the Botanic Garden of Geneva. When de Candolle unpacked the cactus he thought it was covered in fungus, but discovered that the white spots were actually tufts of hair or trichomes. These woolly scales may help the cactus collect water and protect it against the sun, but they also provide camouflage. This species is the most densely covered of all the *Astrophytum* cacti, and also the spiniest. It is now rare in the wild.

SIZE 1.5 m (5 ft)
HABITAT Semi-desert scrub
DISTRIBUTION N.E. Mexico
LEAF TYPE Spines

< ROOT SYSTEM
Fibrous and shallow roots help the cactus to absorb water from a large area, essential in an environment where after brief showers only a few centimetres of soil are wet.

OUTER PETALS >
The numerous, narrow outer petals of the flower are pale yellow and have brown tips. The flower itself grows to 11 cm (4½ in) in diameter.

< ∨ WOOLLY SCALES
This cactus has white, scale-like tufts of trichomes arranged in bands between its ribs. They are densely woolly in young plants but become sparse with age.


petal
stamen (male part that produces and releases pollen)
stigma
style (female part that connects the stigma to the ovary)
ovary

> FLOWER SECTION
The yellow petals have a broad oblong shape with a slightly serrated apex. The flower has a yellow carpel (the female reproductive organs, made up of the stigma, style, and ovary) and yellow stamens.

^ OVARY
Located below all the other reproductive parts of the flower, the ovary contains ovules that develop into seeds.

^ STIGMA
The flower has a single stigma with 7–12 lobes. This is the part of the flower used to catch pollen. The stigma is about 1.5 cm (½ in) long.

DEPTFORD PINK
Dianthus armeria
F: Caryophyllaceae
Inhabiting dry grassland, especially on light sandy soils in much of Europe, Deptford pink has starry flowers with toothed petals.

CORNCOCKLE
Agrostemma githago
F: Caryophyllaceae
A native of E. Mediterranean countries, corncockle was formerly a widespread cornfield weed, but is now much rarer.

COW BASIL
Vaccaria hispanica
F: Caryophyllaceae
An increasingly rare weed of grain fields in Europe and Asia, this annual herb has pink flowers and bluish green leaves.

SEA SANDWORT
Honckenya peploides
F: Caryophyllaceae
A fleshy prostrate species, sea sandwort is found on coastal sand and shingle in Europe, Asia, and N. America.

THYME-LEAVED SANDWORT
Arenaria serpyllifolia
F: Caryophyllaceae
Found in bare or disturbed ground in Europe, temperate Asia, and N. America, this species gets its common name from its tiny leaves.

pink, or occasionally white, flower
flower stalk lengthens as flower matures
20 cm
8 in
four or five small green leaves per shoot
10 cm/4 in
central cushion has long tap root

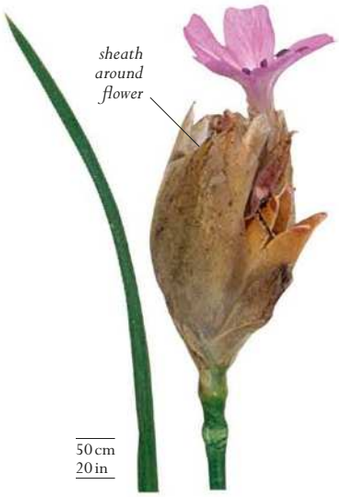
ALPINE CAMPION
Viscaria alpina
F: Caryophyllaceae
This native of the European Alps, Pyrenees, and subarctic areas of Europe, W. Asia, and N. America grows on mineral-rich rocks.

RAGGED ROBIN
Silene flos-cuculi
F: Caryophyllaceae
Divided petals give ragged robin its name. It is a European species found in marshy fields and damp ground.

FIELD MOUSE-EAR
Cerastium arvense
F: Caryophyllaceae
This is a native of dry grassland in Europe, N. Africa, N. America, and W. temperate Asia.

MOSS CAMPION
Silene acaulis
F: Caryophyllaceae
Cushion-forming and moss-like, moss campion grows on mountains in W., C., and N. Europe, as well as Asia, and N. America.

BLADDER CAMPION
Silene vulgaris
F: Caryophyllaceae
Named for its inflated calyx, bladder campion inhabits open grassy places in Europe, N. Africa, and temperate regions of Asia.



CHILDING PINK
Petrorhagia nanteuilii
F: Caryophyllaceae

The flowers of childing pink open one at a time. This species inhabits dry grassy places on sandy soils in W. Europe.

SOAPWORT
Saponaria officinalis
F: Caryophyllaceae

Once used to make soap, this species is found along streams and damp ground in S. Europe and W. Asia.

COMMON CHICKWEED
Stellaria media
F: Caryophyllaceae

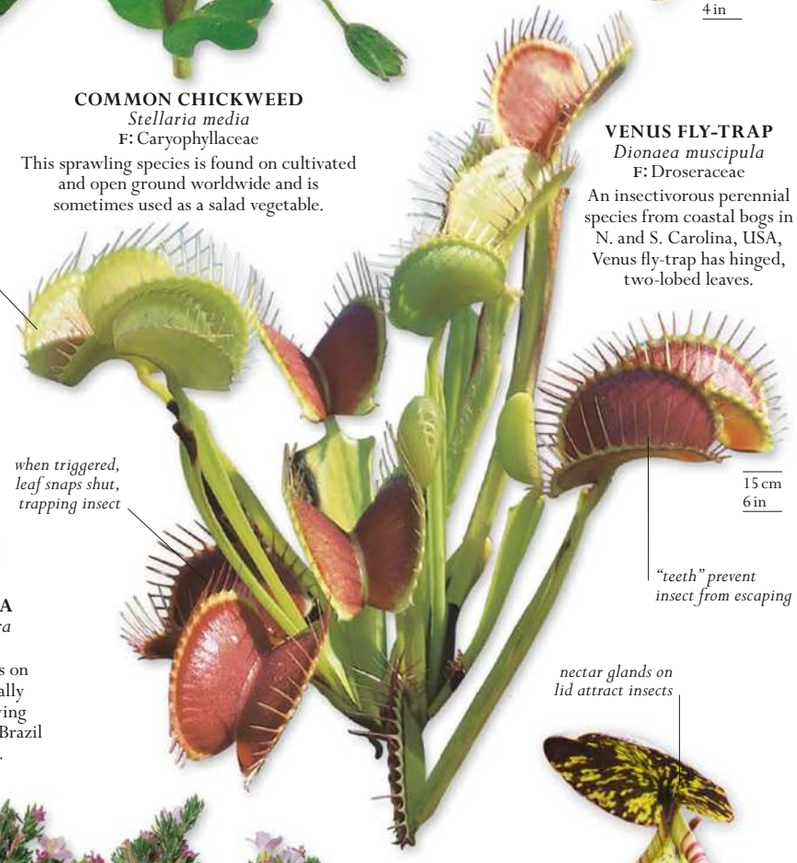
This sprawling species is found on cultivated and open ground worldwide and is sometimes used as a salad vegetable.

ROUND-LEAVED SUNDEW
Drosera rotundifolia
F: Droseraceae

Inhabiting open boggy moorland and heathland in Europe, N. Asia, and N. America, this insectivorous species has leaves with numerous sticky hairs covered in insect-dissolving enzymes.

BOUGAINVILLEA
Bougainvillea glabra
F: Nyctaginaceae

What seem to be petals on bougainvillea are actually bracts. This slow-growing evergreen climber from Brazil is widely cultivated.

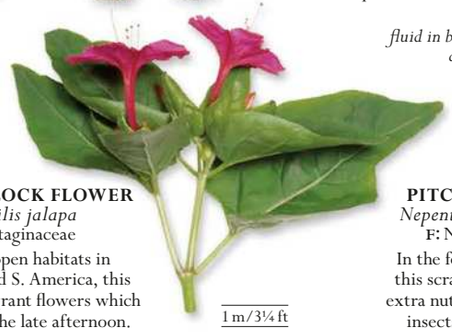

trap triggered by hairs on leaf surface
when triggered, leaf snaps shut, trapping insect
15 cm
6 in
"teeth" prevent insect from escaping

VENUS FLY-TRAP
Dionaea muscipula
F: Droseraceae

An insectivorous perennial species from coastal bogs in N. and S. Carolina, USA, Venus fly-trap has hinged, two-lobed leaves.

SEA HEATH
Frankenia laevis
F: Frankeniaceae

A mat-forming species, sea heath grows on bare sandy ground in the drier parts of salt marshes in W. Europe and N.W. Africa.



FOUR O'CLOCK FLOWER
Mirabilis jalapa
F: Nyctaginaceae

From dry open habitats in tropical C. and S. America, this species has fragrant flowers which open during the late afternoon.

nectar glands on lid attract insects
insects slither off slippery rim into pitcher
12 m
40 ft
fluid in base of pitcher digests insects
pitcher grows from tendril at end of leaf

PITCHER PLANT
Nepenthes stenophylla
F: Nepenthaceae

In the forests of Borneo, this scrambling vine gets extra nutrients by trapping insects in its pitchers.

»

SULPHUR FLOWER
Eriogonum umbellatum
F: Polygonaceae
Inhabiting well-drained montane forest and scrub in Canada and N. and W. USA, this spreading mat-forming species has long-lasting flowers.

ST CATHERINE'S LACE
Eriogonum giganteum
F: Polygonaceae
With long-lasting flowerheads much visited by butterflies, this plant grows wild only on the Channel Islands of California, USA.

COMMON BUCKWHEAT
Fagopyrum esculentum
F: Polygonaceae
Buckwheat originated in temperate areas of Asia, and is cultivated for its seeds, which are made into flour and also fed to birds.

BLACK BINDWEED
Fallopia convolvulus
F: Polygonaceae
Growing on waste and cultivated ground, black bindweed is native to much of Europe, N. Africa, and temperate Asia.

CURLED DOCK
Rumex crispus
F: Polygonaceae
Curled dock inhabits grassy places, waste ground, and coastal shingle in Europe, Asia, and N. Africa. It can be an invasive species.

KNOTGRASS
Polygonum aviculare
F: Polygonaceae
This spreading species of open cultivated and bare ground in Europe and Asia grows on coasts and inland.

MOUNTAIN SORREL
Oxyria digyna
F: Polygonaceae
Inhabiting damp ledges and streamsides on mountains in Arctic and temperate regions of the northern hemisphere, mountain sorrel is often tinged red.

COMMON BISTORT
Persicaria bistorta
F: Polygonaceae
Inhabiting grassy areas in much of Europe and C. Asia, common bistort has dense cylindrical flower spikes.

CORAL VINE
Antigonon leptopus
F: Polygonaceae
This fast-growing species climbs by means of tendrils. It lives in tropical forest and scrub in Mexico.

POKEWEED
Phytolacca americana
F: Phytolaccaceae
With poisonous fruits resembling blackberries, this unpleasant-smelling perennial is native to open and shady parts of eastern N. America and Mexico.

CHINESE RHUBARB
Rheum palmatum
F: Polygonaceae
With enormous roots and large, poisonous leaves, Chinese rhubarb inhabits streamsides and damp ground in mountainous areas in China.

SUMMER PURSLANE
Portulaca oleracea
F: Portulacaceae
Native to the Mediterranean region and Africa, but widely introduced elsewhere, purslane is an edible, fleshy species of disturbed ground.

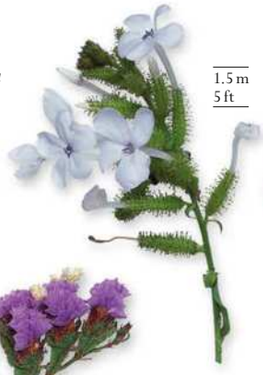
PHEMERANTHIS SEDIFORMIS
F: Talinaceae
The flowers of this prostrate species open in the afternoon. Dry grassland and scrub in western N. America are its home.

LEWISIA BRACHYCALYX
F: Montiaceae
Native to damp stony meadows in mountainous areas of S.W. USA, this species has a basal rosette of fleshy leaves.

SPRING BEAUTY
Claytonia perfoliata
F: Montiaceae
Also known as miner's lettuce, this native of cultivated and bare ground in western N. America, Mexico, and Guatemala has two fused leaves beneath the flowers.

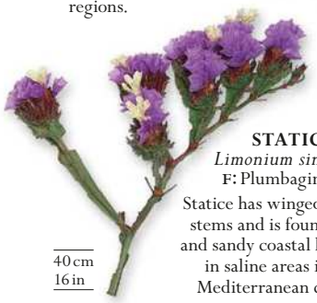
FRINGED REDMAIDS
Calandrinia ciliata
F: Montiaceae
Native to grasslands from S. Canada to Argentina, this species has escaped to the Falkland Islands and is also grown in gardens.

CEYLON LEADWORT
Plumbago zeylanica
F: Plumbaginaceae
Growing mainly in open, human-created habitats, this scrambling shrub is found throughout tropical and subtropical regions.



TAMARISK
Tamarix gallica
F: Tamaricaceae
Usually coastal, tamarisk also grows in saline areas inland. It originates from S. Europe, N. Africa, and the Canary Islands, and is planted elsewhere.

JOJOBA
Simmondsia chinensis
F: Simmondsiaceae
Deserts in Arizona and California, USA, and Mexico are home to jojoba, a species often cultivated for its oil.



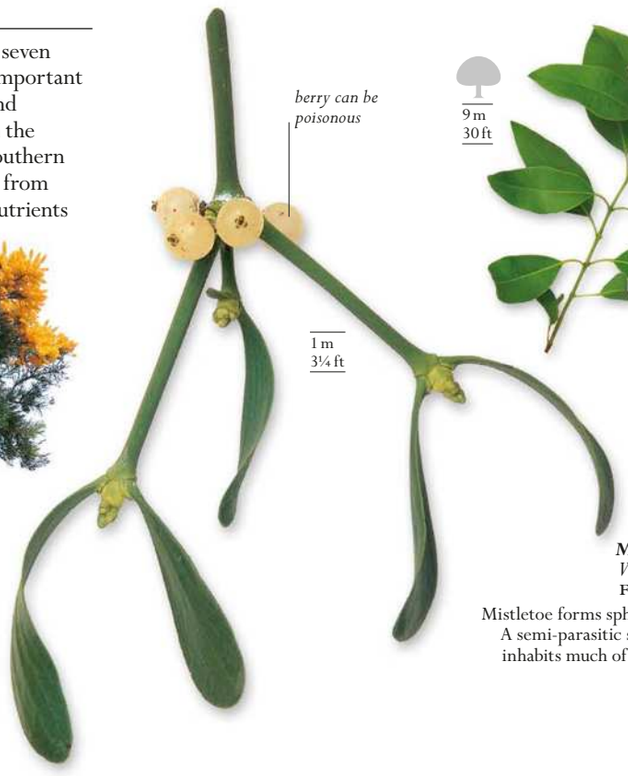
STATICE
Limonium sinuatum
F: Plumbaginaceae
Statice has winged branching stems and is found in rocky and sandy coastal habitats and in saline areas inland in Mediterranean countries.

SEA PINK
Armeria maritima
F: Plumbaginaceae
In much of W. Europe, thrift, or sea pink, inhabits coastal rocks and cliffs, salt marshes, and mountains. It is a cushion-forming species.

SANTALALES

Found mainly in the tropics and subtropics, the seven families in the order Santalales include several important timber trees. They also feature many parasitic and semi-parasitic plants, notably the 900 species in the showy mistletoe family (Loranthaceae) of the southern hemisphere. These live attached to other plants, from which they obtain all or most of the water and nutrients they need for growth.

FIRE TREE
Nuytsia floribunda
F: Loranthaceae
This species is semi-parasitic, deriving moisture and nutrients from the roots of surrounding plants in woodland in S.W. Australia.



MISTLETOE
Viscum album
F: Santalaceae
Mistletoe forms spherical masses on tree branches. A semi-parasitic species with white berries, it inhabits much of Europe, N. Africa, and Asia.

SANDALWOOD
Santalum album
F: Santalaceae
Cultivated for its wood and fragrant oil, this semi-parasitic tree grows in dry, rocky areas in Asia and Australia.

OSYRIS
Osyris alba
F: Santalaceae
This broom-like semi-parasitic species with fragrant flowers is native to S. Europe, N. Africa, and S.W. Asia, inhabiting dry, rocky places.

CORNALES

Seven families constitute the revised order Cornales. Five of these are small and relatively insignificant, one with just a single species of evergreen tree from Africa. The main family is the dogwood family (Cornaceae), a loose taxonomic grouping of shrubs and small trees found in temperate zones and on tropical mountains. The hydrangea family (Hydrangeaceae) includes several popular garden plants.

HYDRANGEA
Hydrangea macrophylla
F: Hydrangeaceae
Native to Japan, this showy shrub is cultivated for its rounded clusters of rose, lavender, blue, and even white flowers.

1.5 m/5 ft

FLOWERING DOGWOOD
Cornus florida
F: Cornaceae
The showy white "petals" of this N. American dogwood tree are bracts (specialized leaves) around clusters of tiny flowers.

12 m
40 ft

DOVE TREE
Davidia involucrata
F: Nyssaceae
This small flowering tree from China is impressive in bloom, with flowerheads 2 cm (¾ in) across, surrounded by creamy bracts.

25 m
80 ft

MOCK ORANGE
Philadelphus sp.
F: Hydrangeaceae
Around 45 species of this shrubby genus, named for their orange-blossom fragrance, are native to Asia, western N. America, and Mexico.

4.5 m
15 ft

ERICALES

Comprising 22 families, the Ericales is a major order, both economically and as one of the world's main herbaceous groups. It is named after its largest member, the heather family (Ericaceae), with over 4,000 species of flowering shrubs mainly in acid soils. It also includes 900 species in the primrose family (Primulaceae), largely confined to north temperate mountain regions; herbs and shrubs in the Jacob's ladder family (Polemoniaceae); and carnivorous plants in the pitcher plant family (Sarraceniaceae).

1 m
3¼ ft

JACOB'S LADDER
Polemonium caeruleum
F: Polemoniaceae
This tall perennial has cup-shaped lavender or white flowers. It grows in rocky and grassy places in Europe and N. Asia.

1 m/3¼ ft

PERENNIAL PHLOX
Phlox paniculata
F: Polemoniaceae
A pyramidal cluster of trumpet-shaped, pink or lavender flowers top the stem of this perennial, native to open woods in S.E. USA.

TREE RHODODENDRON
Rhododendron arboreum
F: Ericaceae

There are about 1,000 species of *Rhododendron*, most with leathery, evergreen leaves and showy flowers. Many, like this one, come from the Himalayas.

HEATHER
Calluna vulgaris
F: Ericaceae

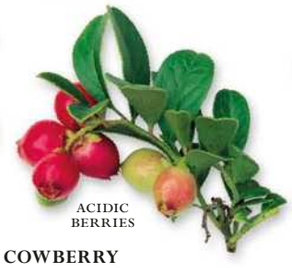
This evergreen shrub, with spikes of pale purple flowers, dominates vast areas of moorland in N. Europe, eastwards into Asia.

DORSET HEATH
Erica ciliaris
F: Ericaceae

One of several similar spiky ericas, this species is known from S. England (including Dorset), as well as W. Ireland, France, Iberia, and Morocco.

STRAWBERRY TREE
Arbutus unedo
F: Ericaceae

Although related to heathers, the warty, red fruits of this evergreen Mediterranean tree look remarkably like strawberries but taste insipid.



COWBERRY
Vaccinium vitis-idaea
F: Ericaceae

This neat heather, with leathery leaves and glossy red berries in autumn, is found across N. Europe, Asia, and N. America.

HIMALAYAN PIERIS
Pieris formosa
F: Ericaceae

Formosa means "beautiful", a reference to the hanging clusters of white, urn-shaped flowers on this Asian bush or small tree.

CHECKERBERRY
Gaultheria procumbens
F: Ericaceae

This creeping, aromatic shrub forms patches beneath oaks and conifers in eastern N. America. Its red fruits last through the winter.

SWEET PEPPER BUSH
Clethra alnifolia
F: Clethraceae

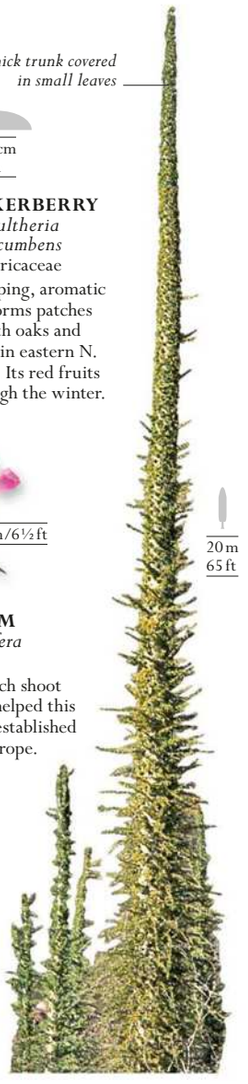
This deciduous shrub grows in wet forests and bogs in eastern N. America. Its leaves turn yellow or orange in autumn.

PERSIMMON
Diospyros virginiana
F: Ebenaceae

This native N. America tree has yellowish white, bell-shaped flowers and produces globular orange fruits, about 4 cm (1½ in) across.

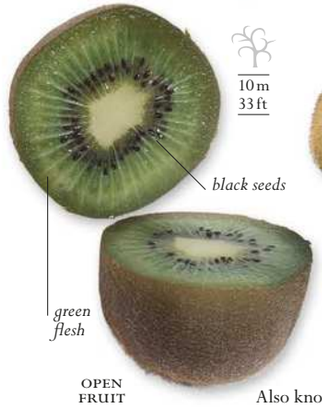
INDIAN BALSAM
Impatiens glandulifera
F: Balsaminaceae

Exploding fruit pods, which shoot their seeds outwards, have helped this Himalayan species become established by rivers in most of Europe.



BOOJUM TREE
Fouquieria columnaris
F: Fouquieriaceae

This strange tree is mainly confined to Baja California, USA. Its stem and upright, spiny branches are green and can photosynthesize.



KIWI
Actinidia chinensis
F: Actinidiaceae

Also known as Chinese gooseberry, this woody climber was introduced from China to New Zealand, where the berries were sold as "kiwi fruits".

BRAZIL NUT
Bertholletia excelsa
F: Lecythidaceae

Brazil "nuts" are actually seeds inside this S. American tree's hard, cannonball-like fruits. In the wild, agoutis (large rodents) open the fallen fruits.

HOODED PITCHER PLANT

Sarracenia minor

This insectivorous plant is highly adapted to living in nutrient-poor, acidic swamps and bogs, digesting insects to obtain phosphorus and nitrogen from their bodies. Insects are attracted by nectar into the pitcher, the long, thin, tubular, modified leaf from which the plant gets its name. The interior of the pitcher is covered in a slippery waxy coating and downward-pointing hairs that become coarser nearer the bottom of the tube. The insects fall in and, unable to get out, eventually die from exhaustion. Digestive glands in the tube walls exude enzymes which break down the insects, resulting in a liquid slurry which is then absorbed into the leaf, providing the pitcher plant with valuable nutrients.

petal
ovary forms seed capsules when fertilized
bowl-shaped style from which insects collect pollen
flower held well above deadly pitchers

SIZE Up to 30 cm (12 in) tall
HABITAT Swampy areas in pinewoods and savannas
DISTRIBUTION S.E. USA
LEAF TYPE Hooded, narrow, funnel-shaped "pitcher"

FLOWER ∨
The flowers have five sepals, five yellow petals (which redden as they mature), and a whitish, umbrella-like style. They hang upside down.

SEED CAPSULE ∨
The broad, rough capsules crack open and scatter many tiny knobbly seeds, which are about 3 mm (⅛ in) long.

RHIZOME ∨
The plant's domed pitchers rise up from a horizontally branching, underground stem known as a rhizome.

ROOTS >
The fibrous roots are 20–30 cm (8–12 in) long and grow along the length of the rhizome.

∧ "WINDOWS"
Insects fly towards the bright translucent "windows" or areoles on the upper part of the pitcher, but then slide down into the tube.

∧ INSECT TRAP
Insects caught in the pitcher find it very difficult to escape. The leaf digests the soft parts, but the skeletons remain.

^ IN BLOOM
The yellow, odourless flowers are produced from late March to mid-May. Bees are the main pollinator, and will favour this species over other nearby plants.

reddish purple colours of the hood attract insects to the pitcher

< HOODS
The concave hoods prevent rainwater from filling up the pitcher and also shade the opening, making it harder for trapped insects to find the exit.

nectar glands at the back of the hood

< CARNIVORE AT RISK
The hooded pitcher plant is now a rare and threatened species due to habitat loss. It is found in North Carolina, South Carolina, Georgia, and Florida. There are two varieties: *S. minor* grows to 30 cm (12 in), while *S. minor* var. *okefenokeensis*, with pitchers up to 1.2 m (4 ft) long, is found only at Okefenokee Swamp in Georgia.

EPAULETTE TREE
Pterostyrax hispidus
F: Styracaceae
Native to E. Asia, this large-leaved, deciduous tree is sometimes cultivated for its hanging clusters of fragrant, creamy-white flowers.

SILKY CAMELLIA
Stewartia malacodendron
F: Theaceae
Named after its silkily haired young stems, this deciduous shrub or tree grows in woodland in S.E. USA.

GRANTHAM'S CAMELLIA
Camellia granthamiana
F: Theaceae
One of well over 100 *Camellia* species, all from Asia, this endangered tree from China was discovered in 1955.

TEA
Camellia sinensis
F: Theaceae
The dried fermented leaves and buds of this evergreen Asian shrub are used to make tea. Their astringent tannins deter grazing animals.

CREEPING JENNY
Lysimachia nummularia
F: Primulaceae
From Sweden to the Caucasus, the spreading stems of this perennial creep amongst vegetation in damp grassy places, shady hedgerows, and streamsides.

SPANISH CHERRY
Mimusops elengi
F: Sapotaceae
This evergreen Indian tree is planted in tropical countries for its fragrant flowers. Its durable wood is used in shipbuilding and construction.

HOODED PITCHER PLANT
Sarracenia minor
F: Sarraceniaceae
Pitcher plants trap and digest insects to supplement their nutrient-poor soils. This species is native to S.E. USA.

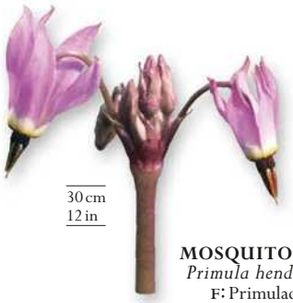
PARROT PITCHER PLANT
Sarracenia psittacina
F: Sarraceniaceae
Sarracenia species grow wild only in N.E. America. The pitchers of this species, found from Florida to Louisiana, form horizontal traps.

CORALBERRY
Ardisia crenata
F: Primulaceae
A greenhouse favourite for its long-lasting, bright berries, this Asian shrub has become an invasive pest in Hawaii, Florida, and Texas, USA.

COBRA PLANT
Darlingtonia californica
F: Sarraceniaceae
The only species of *Darlingtonia*, this carnivorous plant grows in coastal bogs and beside mountain streams in W. USA.

SCARLET PIMPERNEL
Anagallis arvensis
F: Primulaceae
Just as likely to have deep blue as scarlet flowers, this sprawling plant now grows in disturbed ground virtually worldwide, except the tropics.

HAIRY ANDROSACE
Androsace villosa
F: Primulaceae
In a genus of arctic-alpines, this perennial of mountains from Europe to the Himalayas is known for its dense white flowerheads and silky leaves.



MOSQUITO BILLS
Primula hendersonii
F: Primulaceae
One of a group of North American primroses called "shooting stars" from their rocket or dart shapes, this species has magenta to white flowers.

WILD PRIMROSE
Primula vulgaris
F: Primulaceae
Supposedly the *prima rosa,* or "first flower" of spring, this perennial grows in woodland clearings and hedgebanks throughout W. and S. Europe.

NORTHERN PRIMROSE
Primula scandinavica
F: Primulaceae
Growing on mountain slopes in Norway and Sweden, this resembles the commoner European bird's-eye primrose, but is much smaller.

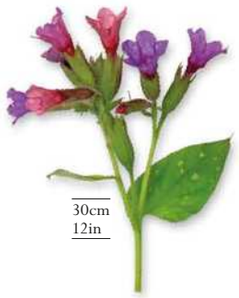
COWSLIP
Primula veris
F: Primulaceae
A typical primrose, with a head of up to 30 nodding flowers, cowslip grows in lime-rich meadows in S. Europe and temperate Asia.

HARDY CYCLAMEN
Cyclamen hederifolium
F: Primulaceae
Cyclamen leaves grow from underground stems, and their tubular autumn flowers have back-folded petals. This species grows in bushy shady places in S. Europe.

BORAGINALES

Because of uncertainties over how the forget-me-not family (Boraginaceae) relates to other families, a new order, Boraginales, was proposed in 2016, just for this one family of around 2,700 species. They range from small annual herbs to large trees, often with conspicuous hairs and swollen bases on their stems or leaves. Some species are edible, and dyes are produced from others.

TANSY PHACELIA
Phacelia tanacetifolia
F: Boraginaceae
This annual of dry places in S.W. USA flowers prolifically after rain. More than 160 members of its genus are found in N. America.

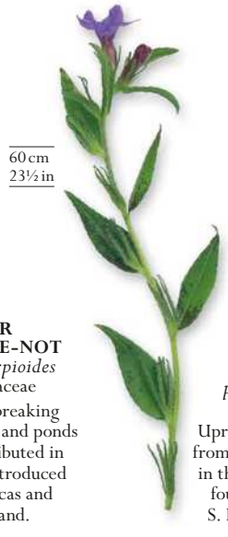


COMMON LUNGWORT
Pulmonaria officinalis
F: Boraginaceae
With blotched leaves supposedly resembling unhealthy lungs, and once thought to be efficacious against tuberculosis, this perennial grows in shady places throughout C. Europe.

BORAGE
Borago officinalis
F: Boraginaceae
Stiff hairs cover the stem and leaves of this S. European wayside plant, also cultivated for ornament and its oil-rich seeds.

COMMON COMFREY
Symphytum officinale
F: Boraginaceae
Symphytum means "growing together", named because this perennial of damp ground across Eurasia was traditionally used in the treatment of injuries.

WATER FORGET-ME-NOT
Myosotis scorpioides
F: Boraginaceae
This surface-breaking plant of streams and ponds is widely distributed in Eurasia, and introduced to the Americas and New Zealand.



PURPLE GROMWELL
Lithospermum purpureocaeruleum
F: Boraginaceae
Upright flower stems grow from creeping ground stems in this woodland perennial found on chalky soils in S. Europe and S.W. Asia.

VIPER'S-BUGLOSS
Echium vulgare
F: Boraginaceae
Widespread in grassy places in Europe and temperate Asia, this rough-haired biennial has pinkish flower buds but deep blue flowers.

GARRYALES

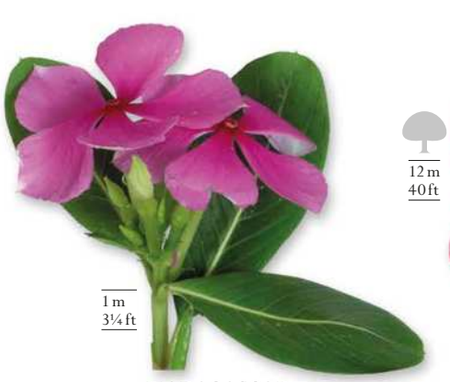
Any classification system raises anomalies, and the order Garryales is one of these. Once placed in the Cornales, modern genetic investigation separated this order of two families and around 20 species. The silky tassel family (Garryaceae) includes two genera: *Garrya* from N. America and *Aucuba* from E. Asia. The Eucommiaceae covers just one species: *Eucommia ulmoides*, a tree of Chinese mountain forests.

SPOTTED LAUREL
Aucuba japonica
F: Garryaceae
Some cultivars of this ornamental Japanese shrub grow yellow-blotched leaves. Plants are either male, with upright flower spikes, or female with small, clustered flowerheads.

SILK-TASSEL BUSH
Garrya elliptica
F: Garryaceae
Growing in coastal scrub in California and Oregon, USA, this small tree has showy, grey-green male catkins and shorter, silvery female catkins.

GENTIANALES

The order name celebrates the gentians of mountains and gardens, but the Gentianaceae family has only around 1,600 members. The madder family (Rubiaceae) is the largest in the order, with over 13,000 species, including tropical shrubs such as coffee. The oleander family (Apocynaceae), strychnine family (Loganiaceae), and jessamine family (Gelsemiaceae) complete the order.



MADAGASCAR PERIWINKLE
Catharanthus roseus
F: Apocynaceae
The leaves of this garden ornamental, endangered in its native Madagascar, contain tiny amounts of alkaloids used to treat childhood leukaemias. This use has saved it from extinction.

COMMON FRANGIPANI
Plumeria rubra
F: Apocynaceae
Native from Mexico to Venezuela, the flowers of this ornamental tree are fragrant at night and attract sphinx moths for pollination.

GREATER PERIWINKLE
Vinca major
F: Apocynaceae
Long, rooting stems of this evergreen perennial creep across woodland floors in S. and C. Europe and N. Africa.

OLEANDER
Nerium oleander
F: Apocynaceae
All parts of this evergreen shrub are poisonous. It grows by streams from the Mediterranean to China, producing clusters of fragrant pink flowers.

BEAD PLANT
Nertera granadensis
F: Rubiaceae
Named for its small, bead-like fruits, this perennial with tiny, green flowers is native to Australia, New Zealand, Pacific islands, and S. America.

BUTTERFLY WEED
Asclepias tuberosa
F: Apocynaceae
Native Americans chewed the roots of this showy perennial as a cure for pleurisy. It grows in fields and on roadsides in N. America.

CLEAVERS
Galium aparine
F: Rubiaceae
Prickles on the stem and leaf margins attach to animal fur, dispersing parts of this agricultural weed of Europe and Asia.

CROSSWORT
Cruciata laevipes
F: Rubiaceae
With stem leaves in cross-like whorls and clustered, honey-scented flowers, this perennial grows in grassy places across Europe and Asia.

QUININE TREE
Cinchona calisaya
F: Rubiaceae
The anti-malaria drug quinine comes from the bark of this S. American tree. Seeds were smuggled to Asia in the mid 19th century for cultivation there.

COFFEE SHRUB
Coffea arabica
F: Rubiaceae
Native to Ethiopia but transported elsewhere for cultivation, this evergreen shrub produces crimson drupes (stoned fruits) within which are two seeds (coffee beans).

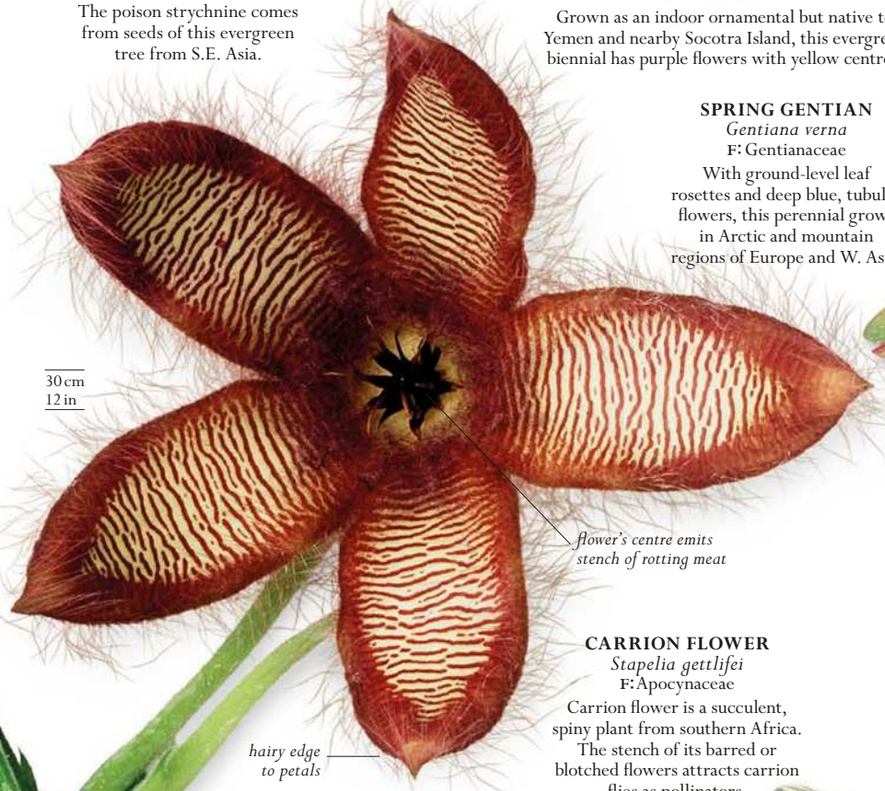
CAPE JASMINE
Gardenia jasminoides
F: Rubiaceae
Originating in Asia, this evergreen shrub has fragrant, waxy, tubular white flowers that turn yellow with age. These ripen to berry-like fruits.

STRYCHNINE
Strychnos nux-vomica
F: Loganiaceae
The poison strychnine comes from seeds of this evergreen tree from S.E. Asia.

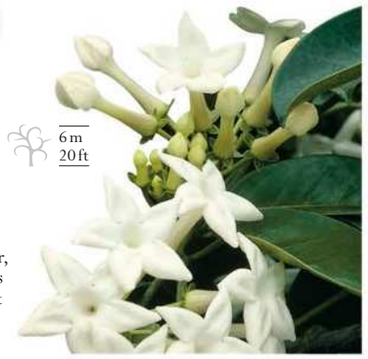
PERSIAN VIOLET
Exacum affine
F: Gentianaceae
Grown as an indoor ornamental but native to Yemen and nearby Socotra Island, this evergreen biennial has purple flowers with yellow centres.

SPRING GENTIAN
Gentiana verna
F: Gentianaceae
With ground-level leaf rosettes and deep blue, tubular flowers, this perennial grows in Arctic and mountain regions of Europe and W. Asia.

COMMON CENTAURY
Centaurium erythraea
F: Gentianaceae
Grassy places and dunes from Europe to S.W. Asia are home to this annual with funnel-shaped, five-lobed pink flowers.



basal rosette of leaves



CARRION FLOWER
Stapelia gettlifei
F: Apocynaceae
Carrion flower is a succulent, spiny plant from southern Africa. The stench of its barred or blotched flowers attracts carrion flies as pollinators.

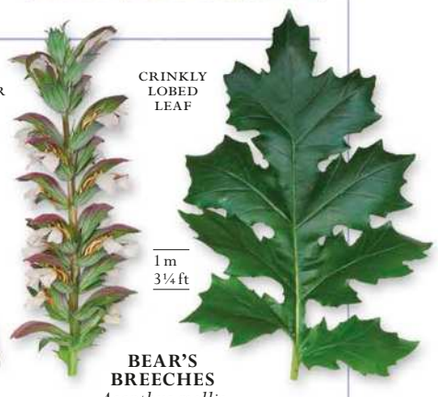
MADAGASCAR JASMINE
Stephanotis floribunda
F: Apocynaceae
Originally from Madagascar, this woody, twining vine is a popular greenhouse plant with leathery leaves and clusters of fragrant, waxy, white flowers.

LAMIALES

Modern taxonomy has expanded the scope of this order to include 25 families, typically with tubular flowers and unequal petal lobes. The largest are the mint family (Lamiaceae, often known by its older name Labiatae) and the figwort family (Scrophulariaceae), each with 5,000–6,000 species. Others include the olive family (Oleaceae) and plantain family (Plantaginaceae).

SHRIMP BUSH
Justicia brandeegeana
F: Acanthaceae
This popular ornamental from Mexico has spikes of white flowers surrounded by overlapping red-bronze bracts (specialized leaves), looking like a large shrimp.

ZEBRA PLANT
Aphelandra squarrosa
F: Acanthaceae
Originating from coastal Brazilian forests, this popular houseplant has pale-veined leaves and spikes of yellow flowers surrounded by yellow bracts.



BEAR'S BREECHES
Acanthus mollis
F: Acanthaceae
This robust perennial of rocky places in the W. Mediterranean has spikes of purple-veined white flowers with a three-lobed lower lip.

BLACK MANGROVE
Avicennia germinans
F: Acanthaceae
This tree forms thickets beside tidal estuaries along tropical Atlantic coasts. Pointed fruits, falling into the mud, sprout new plants.

» LAMIALES

BUGLE
Ajuga reptans
F: Lamiaceae
Growing around Europe, N. Africa, and S.W. Asia, this woodland and meadow perennial produces its flower stems from far-creeping, rooting runners.

SAGE
Salvia officinalis
F: Lamiaceae
This greyish shrub from S.W. Europe and the Balkans is widely cultivated for its pungent leaves, used to flavour foods.

ROSEMARY
Salvia rosmarinus
F: Lamiaceae
From dry Mediterranean habitats, the oils in the leaves of this shrub reduce potential water loss from transpiration. Rosemary is a well-known culinary herb.

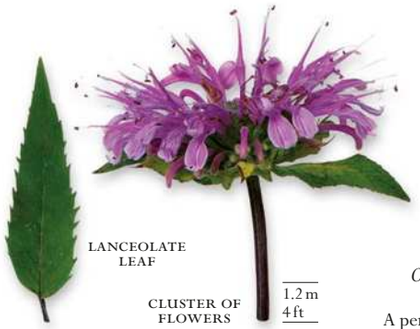
COMMON LAVENDER
Lavandula angustifolia
F: Lamiaceae
This is another evergreen shrub of dry Mediterranean scrub habitats. The water-saving oils in its leaves are valued in perfumery.

BASIL
Ocimum basilicum
F: Lamiaceae
Also known as sweet basil, this is an annual from India and Iran. In cultivation, its pungent leaves are used as a culinary herb.

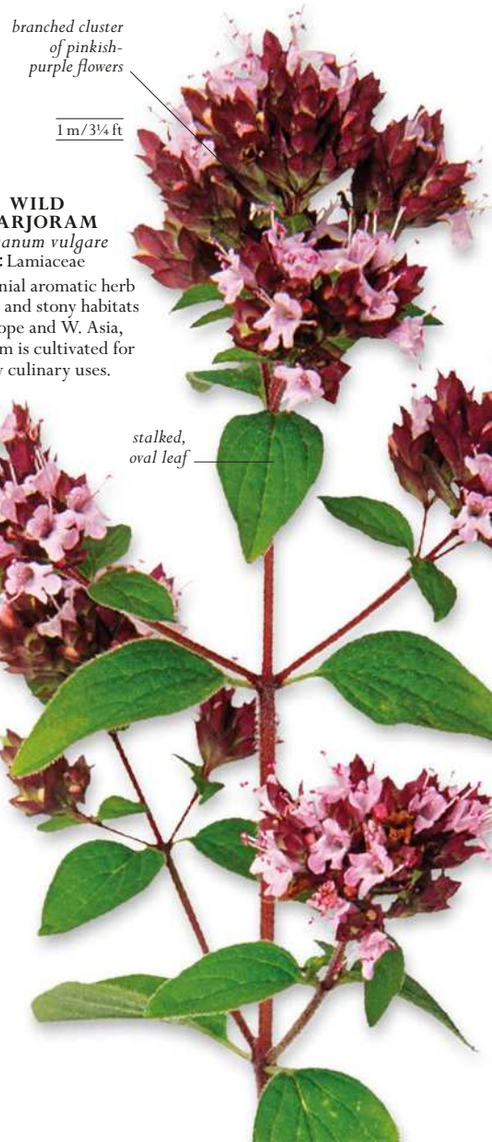
BETONY
Betonica officinalis
F: Lamiaceae
A common hedgerow and grassland herb in most of Europe, the Caucasus, and N. Africa, betony has reddish purple or white flowers.

CHASTE TREE
Vitex agnus-castus
F: Lamiaceae
Chaste tree grows in damp places from S. Europe to Pakistan. It was once thought to preserve chastity, and is used to regulate hormonal functions in herbal medicine.

JERUSALEM SAGE
Phlomis fruticosa
F: Lamiaceae
Native to dry rocky habitats in the E. Mediterranean, this evergreen shrub with grey-felted leaves is a widely grown garden ornamental.



WILD BERGAMOT
Monarda fistulosa
F: Lamiaceae
A minty tea is made from the leaves of this showy American perennial of dry fields and thickets from New England to Texas.



WILD MARJORAM
Origanum vulgare
F: Lamiaceae
A perennial aromatic herb of grassy and stony habitats in Europe and W. Asia, marjoram is cultivated for many culinary uses.

ROUND-LEAVED MINT BUSH
Prostanthera rotundifolia
F: Lamiaceae
This aromatic Australian shrub with circular leaves and pink to purple spring flowers grows in open forests from New South Wales to Tasmania.

COMMON THYME
Thymus vulgaris
F: Lamiaceae
Native to dry rocky places in the W. Mediterranean, this densely branched shrub is used as a culinary herb, and an ingredient in perfumes and soaps.

WATER MINT
Mentha aquatica
F: Lamiaceae
Growing part-submerged in ponds and ditches in Europe, Africa, and S.W. Asia, this herb is one parent of the hybrid peppermint.

OLIVE
Olea europaea
F: Oleaceae

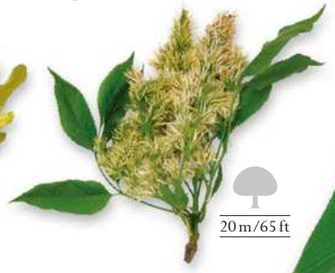
The fleshy fruits of this evergreen Mediterranean tree contain 40 per cent unsaturated oils. Before eating, the olives must be pickled in brine.

15 m/50 ft

3 m/10 ft

GOLDEN BELL
Forsythia suspensa
F: Oleaceae

Also called weeping forsythia, this deciduous shrub has hollow, pendulous stems and yellow flowers. It is native to China and perhaps Japan.



20 m/65 ft

MANNA ASH
Fraxinus ornus
F: Oleaceae

Unusually for an ash, this S. European tree has clusters of showy, white flowers. Manna, a gum from its bark, is used medicinally.

7 m/23 ft

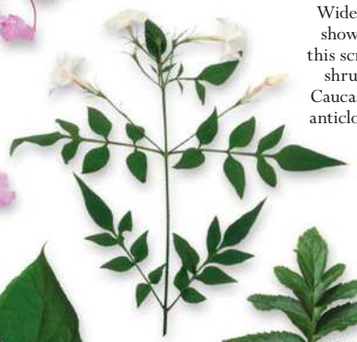
LILAC
Syringa vulgaris
F: Oleaceae

Gardeners have developed many hybrids and varieties of this showy, deciduous tree, found wild on scrubby hill slopes in S.E. Europe.

30 cm
12 in

FALSE AFRICAN VIOLET
Streptocarpus saxorum
F: Gesneriaceae

Originating from Kenya and Tanzania, this evergreen perennial has whorls of small, hairy, almost succulent leaves and five-lobed, trumpet-shaped flowers.



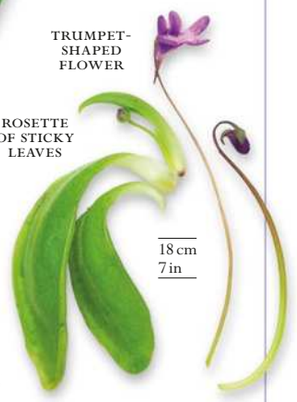
12 m
40 ft

COMMON JASMINE
Jasminum officinale
F: Oleaceae

Widely cultivated for its showy scented flowers, this scrambling, deciduous shrub, found from the Caucasus to China, twists anticlockwise as it climbs.

COMMON BUTTERWORT
Pinguicula vulgaris
F: Lentibulariaceae

This bog plant from N. Europe, Asia, and N. America gains nutrients by trapping and digesting insects on its sticky leaves.



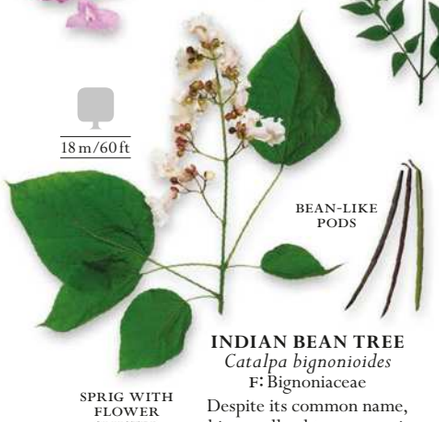
18 cm
7 in

12 m
40 ft

15 cm
6 in

AFRICAN VIOLET
Streptocarpus ionanthus
F: Gesneriaceae

Endangered in the rainforests of tropical E. Africa but popular as houseplants, African violets were once grouped in the genus *Saintpaulia*.



18 m/60 ft

INDIAN BEAN TREE
Catalpa bignonioides
F: Bignoniaceae

Despite its common name, this woodland tree grows in S. USA. It is planted further north and in Europe for its showy flowers.

15 m
50 ft

60 cm
23½ in

HARDY GLOXINIA
Incarvillea delavayi
F: Bignoniaceae

A hardy garden perennial with rosy-purple trumpet flowers, this herbaceous plant grows wild in mountain grasslands of China.

JACARANDA
Jacaranda mimosifolia
F: Bignoniaceae

Originally from Argentina to Bolivia, this tropical tree with hanging clusters of lavender-coloured flowers is widely planted for shade and ornament.

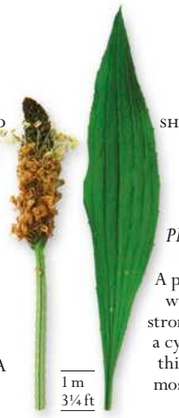
TRUMPET VINE
Campsis x tagliabuana
F: Bignoniaceae

A garden hybrid between a N. American and Asian species, this vigorous climbing shrub has clusters of orange-red, trumpet-shaped flowers.

»

SHRUBBY GLOBULARIA
Globularia alypum
F: Plantaginaceae
Growing in dry, bushy places around the Mediterranean, this poisonous, low, evergreen shrub has globular heads of sweet-scented, blue flowers.

MARE'S-TAIL
Hippuris vulgaris
F: Plantaginaceae
Wholly or partly submerged, this aquatic perennial from Europe, Asia, Africa, and N. and S. America has whorls of narrow leaves up its stem. A rapid grower, mare's-tail is a major garden pest.



RIBWORT PLANTAIN
Plantago lanceolata
F: Plantaginaceae
A plant of grassy places, with narrow, oblong, strongly veined leaves and a cylindrical flowerhead, this perennial grows in most temperate regions.

GREATER PLANTAIN
Plantago major
F: Plantaginaceae
This variable plantain grows in open habitats, including trampled ground in gardens, throughout Europe, N. Africa, and N. and C. Asia.

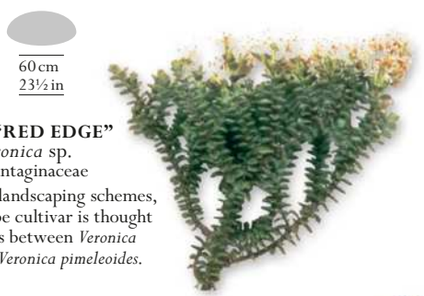
HEATH SPEEDWELL
Veronica officinalis
F: Plantaginaceae
A denizen of European and Asian heathlands, also introduced to N. America, this creeping perennial has small spikes of lilac flowers.

FOXGLOVE
Digitalis purpurea
F: Plantaginaceae
The heart drug digitalis is extracted from the dried leaves of this open-ground biennial from C. and S. Europe and Morocco.

BEARDTONGUE
Penstemon var "Red Garnet"
F: Plantaginaceae
Members of this N. American genus, with colourful, tubular flowers, have been cultivated into many garden varieties.

SNAPDRAGON
Antirrhinum majus
F: Plantaginaceae
Native to S.W. Europe but with many garden varieties, this perennial has tubular, two-lipped flowers, with a yellow or white "throat".

COMMON TOADFLAX
Linaria vulgaris
F: Plantaginaceae
This greyish perennial of grassy banks around Europe and W. Asia has tubular yellow flowers with an orange "throat" and long spur.



***HEBE* "RED EDGE"**
Veronica sp.
F: Plantaginaceae
Often used in landscaping schemes, this hardy hebe cultivar is thought to be a cross between *Veronica albicans* and *Veronica pimeleoides*.

NEW ZEALAND LILAC
Veronica hulkeana
F: Plantaginaceae
This evergreen shrub, also known as a hebe, is a popular garden plant. It has showy stems of lilac flowers, growing wild on cliffs on the eastern side of New Zealand's South Island.

BUTTERFLY BUSH
Buddleja davidii
F: Scrophulariaceae
The tubular flowers of this semi-evergreen shrub, originally from China, are a rich source of nectar, and much visited by butterflies and moths.

SPOTTED EMU BUSH
Eremophila maculata
F: Scrophulariaceae
Widespread on seasonally flooded land across Australia, this much-branched shrub has tubular yellow, orange, or red flowers, with spots inside.

FOXGLOVE TREE
Paulownia tomentosa
F: Paulowniaceae
A deciduous Chinese tree, planted in parks for ornament, *Paulownia* has strong-smelling, trumpet-shaped, two-lobed mauve flowers, paler inside.

MONKEY FLOWER
Erythranthe guttata
F: Phrymaceae
The tubular flowers of this marshland and streamside perennial from western N. America have a three-lobed lower and two-lobed upper lip.

GREAT MULLEIN
Verbascum thapsus
F: Scrophulariaceae
Usually biennial, this sturdy European and Asian plant of waste and rough ground has a dense stem of tubular, five-lobed flowers.

YELLOW RATTLE
Rhinanthus minor
F: Orobanchaceae

A partial parasite whose roots tap grasses for nutrition, this variable, yellow-flowered annual grows in grasslands in northern temperate regions.

PURPLE TOOTHWORT
Lathraea clandestina
F: Orobanchaceae

Lacking green leaves, this parasitic W. European perennial taps the roots of willows and poplars for food. Its flowerheads emerge directly from underground shoots.

LANTANA
Lantana camara
F: Verbenaceae

The tubular flowers of this prickly shrub open yellow or orange then turn red. Native to C. and S. America, it is one of the most invasive weeds in warm regions.

VERVAIN
Verbena officinalis
F: Verbenaceae

Widely distributed in rough grassland in temperate and tropical regions, this stiffly hairy perennial has slender spikes of two-lipped, lilac flowers.

BODINIER'S BEAUTYBERRY
Callicarpa bodinieri
F: Lamiaceae

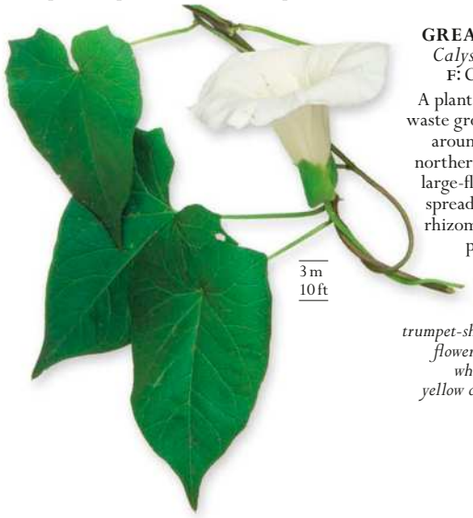
Related to American beautyberry, this Chinese ornamental shrub is grown in gardens for its decorative purple berries, which are bitter but not poisonous.

FLAMING GLORYBOWER
Clerodendrum splendens
F: Lamiaceae

This African vine, with clusters of tubular, red flowers, twines round trees in its native forest habitat, or trellises in gardens.

SOLANALES

The potato family (Solanaceae), an economically important family of up to 4,000 species, dominates the order Solanales. Many species contain poisonous alkaloids. The bindweed family (Convolvulaceae) includes tropical climbers and low-growing herbs. The three other families in this order are the Hydrolaceae, with one genus found only in the Americas; five African trees in the Montiniaceae; and a pan-tropical herb in the Sphenocleaceae.



GREAT BINDWEED
Calystegia sylvaticus
F: Convolvulaceae

A plant of hedgerows and waste ground, even in cities, around the temperate northern hemisphere, this large-flowered perennial spreads by far-creeping rhizomes (underground plant stems).

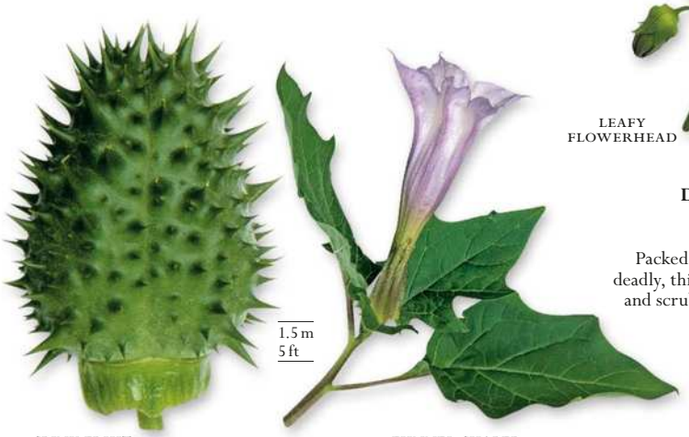
MORNING GLORY
Ipomoea tricolor
F: Convolvulaceae

This twining herbaceous climber from Central America has lobed leaves and funnel-shaped flowers that open only in the morning.

COMMON DODDER
Cuscuta epithymum
F: Convolvulaceae

A Eurasian annual forming a dense network of threadlike, twining stems, parasitic dodder taps into gorse, heather, and other species for food.

» SOLANALES



THORN-APPLE
Datura stramonium
F: Solanaceae

Rank-smelling and highly poisonous, this widespread annual weed is thought to originate from southern N. America.

HENBANE
Hyoscyamus niger
F: Solanaceae

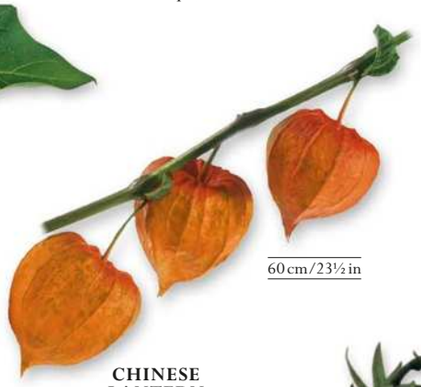
Poisonous, narcotic, and evil-smelling, this annual herb inhabits disturbed ground, especially where cattle graze, in Europe, Asia, and N. Africa.

DEADLY NIGHTSHADE
Atropa belladonna
F: Solanaceae

Packed with powerful narcotics and truly deadly, this tall, perennial herb grows in woods and scrub in Europe, N. Africa, and W. Asia.

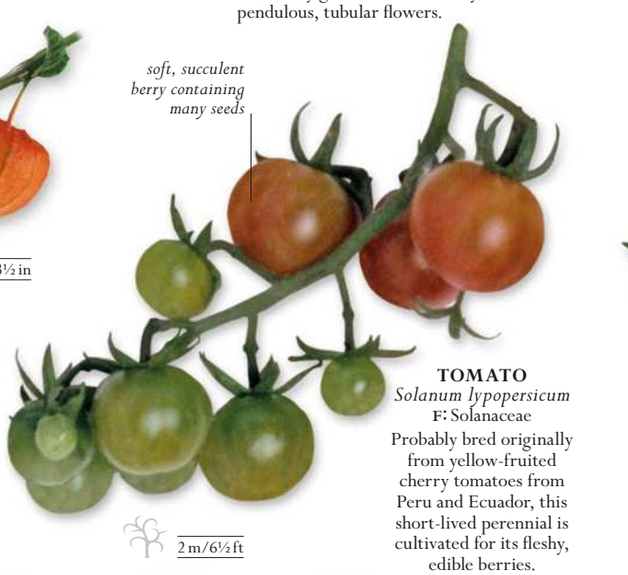
RED ANGELS' TRUMPETS
Brugmansia sanguinea
F: Solanaceae

This evergreen tree from western S. America, with poisonous foliage, is grown in warm, sunny gardens for its showy, pendulous, tubular flowers.



CHINESE LANTERN
Physalis alkekengi
F: Solanaceae

From S. Europe despite its name, this relative of Cape gooseberry is mainly grown for ornament. A lantern-shaped papery case conceals its berry.



TOMATO
Solanum lypopersicum
F: Solanaceae

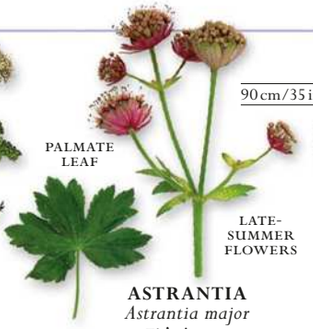
Probably bred originally from yellow-fruited cherry tomatoes from Peru and Ecuador, this short-lived perennial is cultivated for its fleshy, edible berries.

APIALES

The order Apiales is dominated by the highly distinctive and economically important carrot family (Apiaceae, often known by the older name Umbelliferae), with at least 3,500 species. The Araliaceae, consisting of ivies and ginseng, is another large family, while the parchment-bark family, Pittosporaceae, of evergreen shrubs and trees is medium-sized. Four small families, each with fewer than 20 species, complete the order.

WILD ANGELICA
Angelica sylvestris
F: Apiaceae

A typical "umbellifer", this plant has 15–40 umbrella-like spokes supporting its flower-bearing stem. Angelica grows in grassy places in Europe and temperate Asia.



ASTRANTIA
Astrantia major
F: Apiaceae

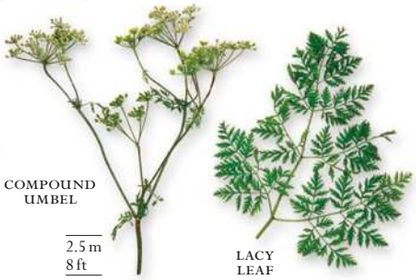
A plant of alpine meadows and open woods in S. Europe, astrantia has showy pinkish bracts (specialized leaves), under its heads of small flowers.

HOGWEED
Heracleum sphondylium
F: Apiaceae

With hollow, hairy stems and umbrella-shaped flowerheads with 10–20 stalks, hogweed grows in roadsides from E. Europe to Britain.

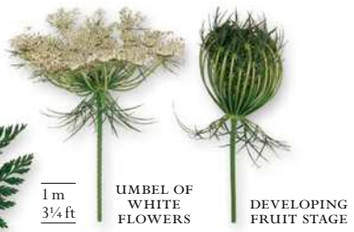
GIANT FENNEL
Ferula communis
F: Apiaceae

This robust, giant perennial, with pungent-smelling, hollow stems, grows in grassy and heathy places around the Mediterranean, Asia, and N. Africa.



HEMLOCK
Conium maculatum
F: Apiaceae

A biennial of wet places in Europe, N. Africa, and Asia, widely introduced elsewhere, hemlock has hollow, purple-spotted stems. All parts are poisonous.



WILD CARROT
Daucus carota
F: Apiaceae

The wild ancestor of cultivated carrots has just slightly swollen tap-roots. It grows throughout Europe, temperate Asia, and N. Africa.

1.2 m
4 ft

CHILLI PEPPER
Capsicum frutescens
F: Solanaceae

Native to Brazil and Bolivia, this small shrub is much cultivated in tropical Asia and equatorial America. Its fruits are chillies.

3 m
10 ft

TOBACCO
Nicotiana tabacum
F: Solanaceae

Originally S. American, this herb is the most common of two species grown for smoking tobacco. The leaves contain nicotine.

1 m
3¼ ft

FLOWERS AND PINNATE LEAVES

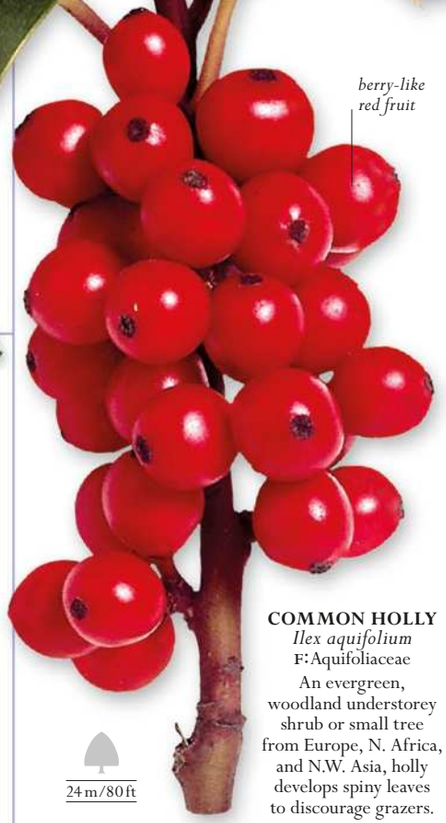
EDIBLE TUBERS

POTATO
Solanum tuberosum
F: Solanaceae

Potatoes are a major food crop. The swollen tubers turn green (and poisonous) in sunlight. The plant was bred from ancestors in the S. American Andes.

mostly spineless upper leaf

berry-like red fruit



24 m/80 ft

COMMON HOLLY
Ilex aquifolium
F: Aquifoliaceae

An evergreen, woodland understorey shrub or small tree from Europe, N. Africa, and N.W. Asia, holly develops spiny leaves to discourage grazers.

10 m
33 ft

KOHUHU
Pittosporum tenuifolium
F: Pittosporaceae

Growing wild in forests and scrub on both islands of New Zealand, this evergreen tree has almost black branches and honey-scented spring flowers.

egg-shaped flowerhead

60 cm/23½ in

leathery, spiny leaf

SEA HOLLY
Eryngium maritimum
F: Apiaceae

Leathery leaves help this sturdy perennial reduce water loss and repel salt spray in sand dunes around Europe, N. Africa, and S.W. Asia.

80 cm/32 in

ORIENTAL GINSENG
Panax ginseng
F: Araliaceae

The root of this Asian herb is used as a traditional remedy. Its species name, *Panax*, comes from the Greek word *panacea*, meaning a cure-all for diseases.

30 m
100 ft

IVY
Hedera helix
F: Araliaceae

An evergreen shrub from Europe and S.W. Asia, ivy climbs up other plants or forms creeping carpets in woods.

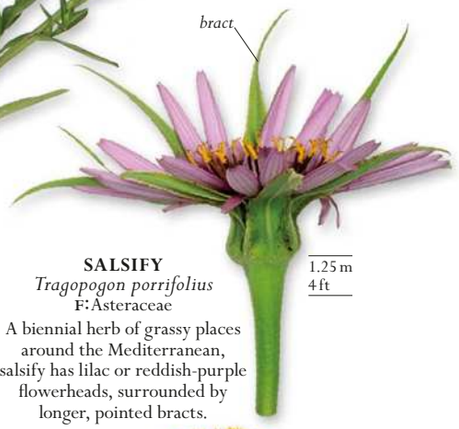
AQUIFOLIALES

The mainly tropical holly family (Aquifoliaceae) includes trees and shrubs with characteristically toothed leaves, and is the main representative of the Aquifoliales order. Other members of this small order are an odd family of twining herbs, the Cardiopteridaceae; three Asian shrubs in the Helwingiaceae; four South American shrubs and trees in the Phyllonomaceae; and a family of tropical trees, the Stemonuraceae.

ASTERALES

Eleven families make up the Asterales. The largest is the daisy family (Asteraceae) with some 25,000 species. Typically, each flower-like head (capitula) has many individual flowers, called florets, surrounded by showy rays. Some of the bellflower family (Campanulaceae) show similar characteristics. This order also includes the bogbean (Menyanthaceae) and fan-flower (Goodeniaceae) families, and seven smaller families.

MICHAELMAS DAISY
Symphotrichum novi-belgii
F: Asteraceae
Previously classified as a species of *Aster*, this showy, variable garden plant is a native of eastern N. America.



SALSIFY
Tragopogon porrifolius
F: Asteraceae
A biennial herb of grassy places around the Mediterranean, salsify has lilac or reddish-purple flowerheads, surrounded by longer, pointed bracts.

SUNFLOWER
Helianthus annuus
F: Asteraceae
Probably Mexican in origin, this tall annual is grown as an ornamental as well as commercially for its seeds that contain 27–40 per cent polyunsaturated oil and 13–20 per cent protein.

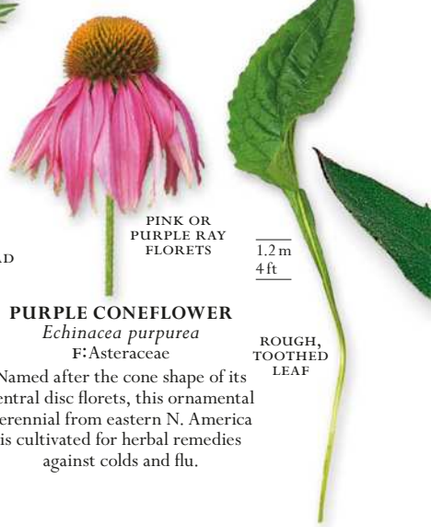
CORNFLOWER
Centaurea cyanus
F: Asteraceae
Probably native to S. Europe and W. Asia, cornflower seeds were inseparable from corn seeds, making it a pestilential agricultural weed before herbicides.

COMMON RAGWORT
Jacobaea vulgaris
F: Asteraceae
Toxic to farm animals and avoided by rabbits, this native perennial from Europe and W. Asia has invaded grasslands almost worldwide.

OXEYE DAISY
Leucanthemum vulgare
F: Asteraceae
One of the most common white-flowered daisies of Europe and W. Asia, this variable patch-forming perennial quickly seeds into disturbed ground.

DAISY
Bellis perennis
F: Asteraceae
Originally from Europe and W. Asia, this short perennial of grazed grasslands and lawns has been transported almost worldwide. It is commonly considered a weed.

COMMON DANDELION
Taraxacum officinale
F: Asteraceae
The name for this familiar weed covers an amazing diversity of minutely differing forms, with perhaps 1,000 recognized "microspecies" in Europe and Asia.



PURPLE CONEFLOWER
Echinacea purpurea
F: Asteraceae
Named after the cone shape of its central disc florets, this ornamental perennial from eastern N. America is cultivated for herbal remedies against colds and flu.

MILK THISTLE
Silybum marianum
F: Asteraceae

This weakly spiny biennial, with white-blotched leaves, grows in waste and cultivated ground around S. Europe, N. Africa, and W. Asia.

CANADIAN GOLDENROD
Solidago canadensis
F: Asteraceae

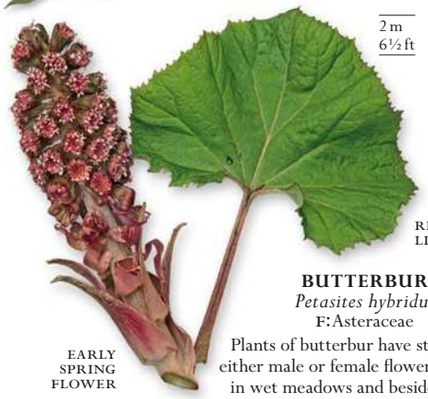
Native to N. America but much grown in gardens, this downy perennial has yellow flowerheads borne in curved, spreading flower spikes.

GLOBE THISTLE
Echinops bannaticus
F: Asteraceae

Native to grassy places in S.E. Europe, this hairy-stemmed perennial has a spherical head of bluish, tubular "disc" florets.

CARDOON
Cynara cardunculus
F: Asteraceae

The fleshy flower base, eaten as globe artichoke, comes from the *scolymus* variety of cardoon, a wasteground perennial from the E. Mediterranean.



BUTTERBUR
Petasites hybridus
F: Asteraceae

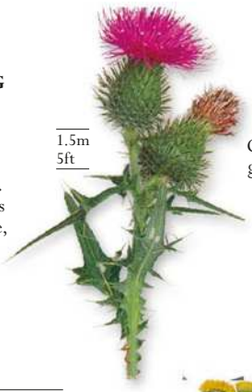
Plants of butterbur have stems with either male or female flowers. It grows in wet meadows and beside streams throughout Europe to Iran.

COTTONWEED
Otanthus maritimus
F: Asteraceae

This shrubby perennial grows in coastal habitats in S. Europe, N. Africa, and S.W. Asia. The common name derives from its woolly stems and leaves.

DENSE BLAZING STAR
Liatris spicata
F: Asteraceae

A plant of damp ground in eastern N. America, this plant is named after its dense, elongated, spike of rose-purple flowerheads.

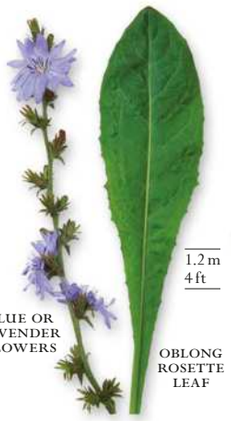


SPEAR THISTLE
Cirsium vulgare
F: Asteraceae

Common in disturbed ground in Europe and W. Asia, this robust perennial with spine-tipped leaves has been carried worldwide by agriculture.

YARROW
Achillea millefolium
F: Asteraceae

Found in grassy places throughout Europe, W. Asia, and N. America, this feathery-leaved perennial has been introduced to Australia and New Zealand.



CHICORY
Cichorium intybus
F: Asteraceae

Introduced almost worldwide from Europe, W. Asia and N. Africa, chicory is cultivated for salad leaves and for a coffee substitute from its roots.

FRENCH TARRAGON
Artemisia dracunculus
F: Asteraceae

Leaves of this bushy, aromatic herb from S.E. Europe, Asia, and N. America are used to flavour fish and other foods.

COTTON LAVENDER
Santolina chamaecyparissus
F: Asteraceae

Widely grown in gardens, this strongly aromatic, dwarf, evergreen shrub with grey-hairy leaves is native to rocky places around the W. Mediterranean.

GARDEN MARIGOLD
Calendula officinalis
F: Asteraceae

This species has been cultivated so long that its origins are unknown. Marigold extract from the flowers is used to treat skin problems.

GARDEN GAZANIA
Gazania sp.
F: Asteraceae

Seventeen species of *Gazania* grow in southern Africa, most in dry habitats. Cultivars like these can survive in gardens with little watering.

STRAND GAZANIA
Gazania rigens
F: Asteraceae

This sprawling, mat-forming perennial often flowers prolifically on dunes and rocky outcrops along the southern Cape coast of South Africa.

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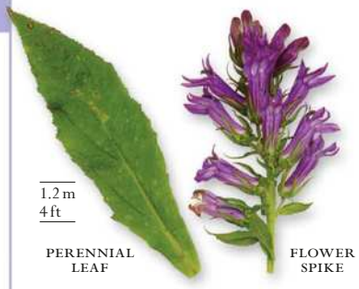
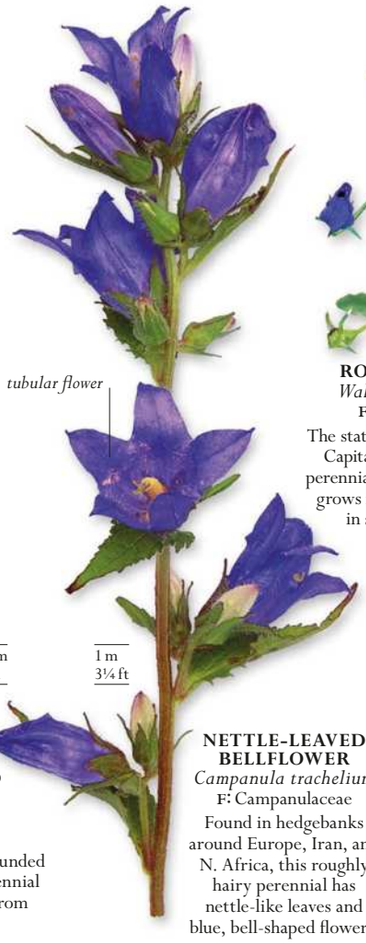


BLUE CARDINAL FLOWER
Lobelia siphilitica
F: Campanulaceae

A showy N. American perennial of woods and meadows from Manitoba to Alabama, this plant was once supposed to cure syphilis.

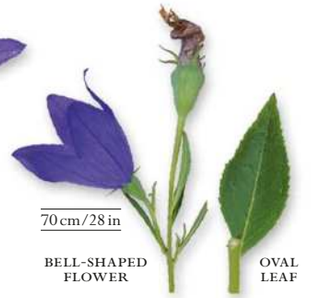


NETTLE-LEAVED BELLFLOWER
Campanula trachelium
F: Campanulaceae

Found in hedgebanks around Europe, Iran, and N. Africa, this roughly hairy perennial has nettle-like leaves and blue, bell-shaped flowers.

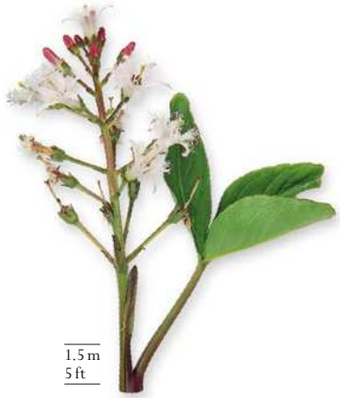
ROYAL BLUEBELL
Wahlenbergia gloriosa
F: Campanulaceae

The state plant of the Australian Capital Territory, this erect perennial with deep blue flowers grows in mountain grasslands in southern Australia.



BALLOON FLOWER
Platycodon grandiflorus
F: Campanulaceae

The only member of its genus, this Asian perennial with blue or white, bell-shaped flowers also comes in many garden varieties.

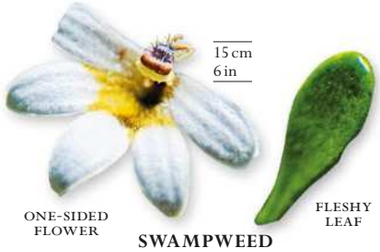


BOGBEAN
Menyanthes trifoliata
F: Menyanthaceae

This far-creeping perennial produces its bean-like fruits in bogs and shallow water in N. America, Greenland, N. Europe, and Asia.

ROUND-HEADED RAMPION
Phyteuma orbiculare
F: Campanulaceae

With dark blue flowers in rounded heads, this unbranched perennial grows in chalk grassland from S. England to Greece.



SWAMPWEED
Selliera radicans
F: Goodeniaceae

This creeping herb is found on coastal sandflats around Chile, Australia, and New Zealand – where it also grows alongside mountain streams.

FRINGED WATER LILY
Nymphoides peltata
F: Menyanthaceae

Unlike true water lilies, this aquatic perennial has smaller yellow flowers with five fringed petals. It is found from Europe to Japan.

DIPSACALES

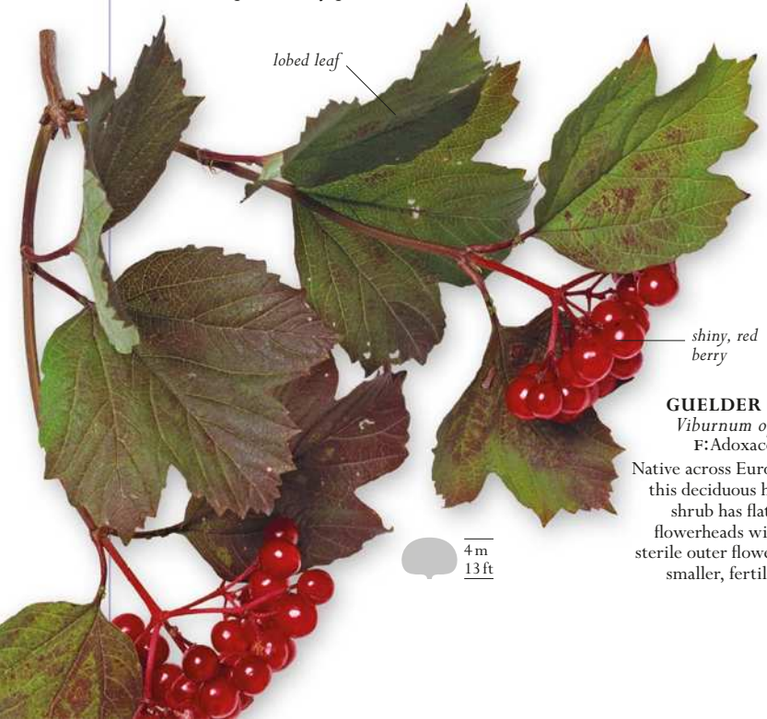
The order Dipsacales is found worldwide, but especially in the northern hemisphere. Its members generally have small flowers, often in compact heads, and include many popular ornamental plants. It consists of two families. The moschatel and viburnum family (Adoxaceae) contains around 200 species, and the honeysuckle family (Caprifoliaceae) has some 860 species, including valerians and teasels that were previously placed in their own families.

MOSCHATEL
Adoxa moschatellina
F: Adoxaceae

Inflorescences of this delicate woodland perennial from Europe, Asia, and N. America have five flowers at right angles (with one facing upwards).

RED VALERIAN
Centranthus ruber
F: Caprifoliaceae

Butterflies appreciate the flowers of this greyish perennial. It is found on coastal rocks and old walls around the Mediterranean, and is naturalized elsewhere.

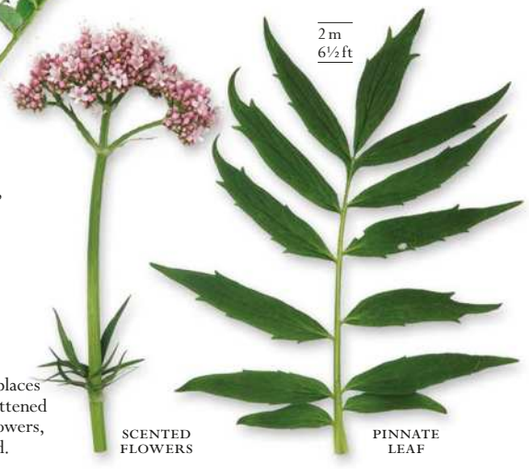


GUELDER ROSE
Viburnum opulus
F: Adoxaceae

Native across Europe to Asia, this deciduous hedgerow shrub has flattened flowerheads with large, sterile outer flowers, around smaller, fertile ones.

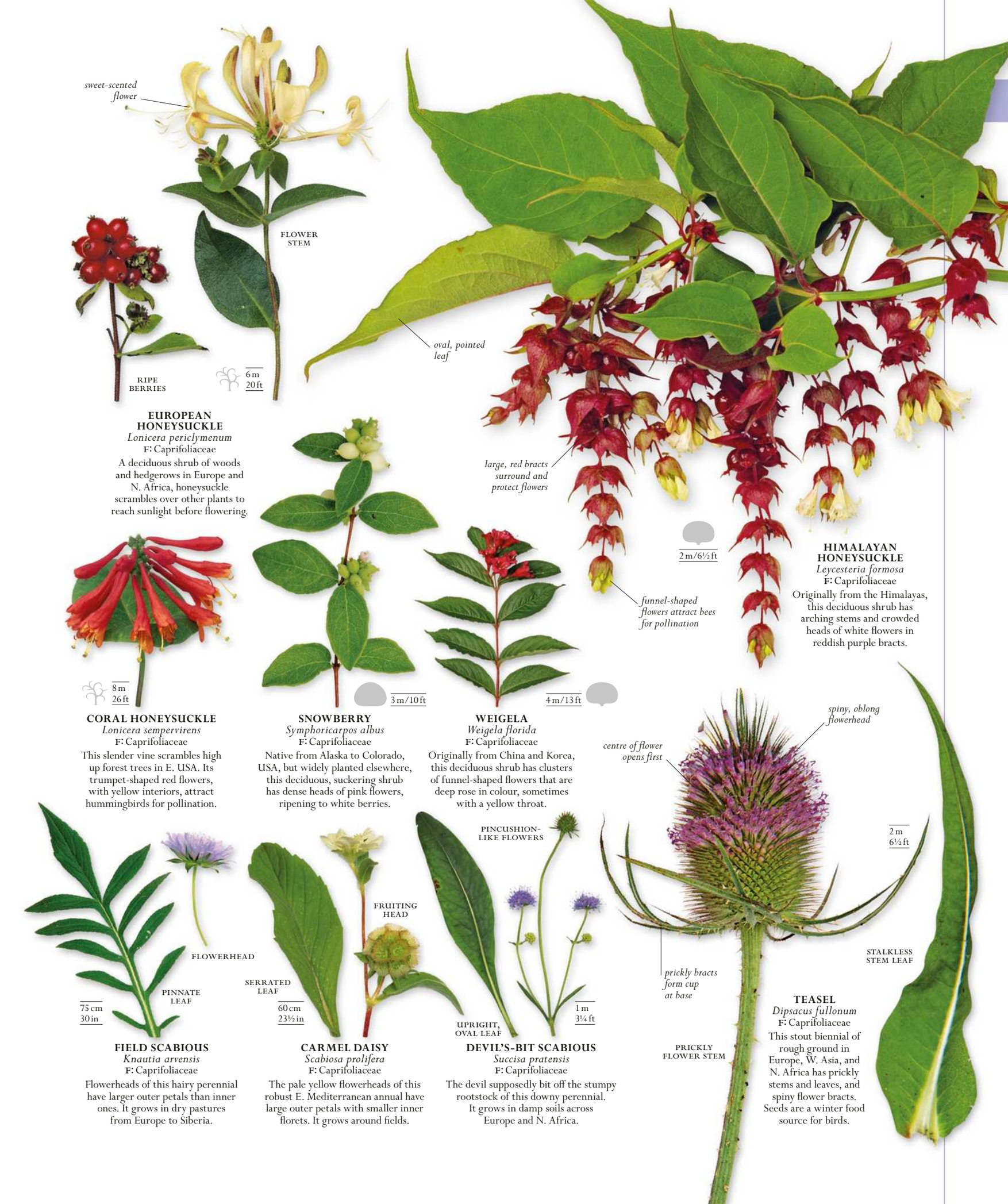
ELDER
Sambucus nigra
F: Adoxaceae

A hedgerow shrub or small tree with lobed leaves and flat-topped flowerheads, elder grows throughout Europe, W. Asia, and N. Africa.



COMMON VALERIAN
Valeriana officinalis
F: Caprifoliaceae

This perennial is found in grassy places from N. Europe into Asia. It has flattened heads of pale pink, five-petalled flowers, which are darker when in bud.



EUROPEAN HONEYSUCKLE
Lonicera periclymenum
F: Caprifoliaceae
A deciduous shrub of woods and hedgerows in Europe and N. Africa, honeysuckle scrambles over other plants to reach sunlight before flowering.

HIMALAYAN HONEYSUCKLE
Leycesteria formosa
F: Caprifoliaceae
Originally from the Himalayas, this deciduous shrub has arching stems and crowded heads of white flowers in reddish purple bracts.

CORAL HONEYSUCKLE
Lonicera sempervirens
F: Caprifoliaceae
This slender vine scrambles high up forest trees in E. USA. Its trumpet-shaped red flowers, with yellow interiors, attract hummingbirds for pollination.

SNOWBERRY
Symphoricarpos albus
F: Caprifoliaceae
Native from Alaska to Colorado, USA, but widely planted elsewhere, this deciduous, suckering shrub has dense heads of pink flowers, ripening to white berries.

WEIGELA
Weigela florida
F: Caprifoliaceae
Originally from China and Korea, this deciduous shrub has clusters of funnel-shaped flowers that are deep rose in colour, sometimes with a yellow throat.

FIELD SCABIOUS
Knautia arvensis
F: Caprifoliaceae
Flowerheads of this hairy perennial have larger outer petals than inner ones. It grows in dry pastures from Europe to Siberia.

CARMEL DAISY
Scabiosa prolifera
F: Caprifoliaceae
The pale yellow flowerheads of this robust E. Mediterranean annual have large outer petals with smaller inner florets. It grows around fields.

DEVIL'S-BIT SCABIOUS
Succisa pratensis
F: Caprifoliaceae
The devil supposedly bit off the stumpy rootstock of this downy perennial. It grows in damp soils across Europe and N. Africa.

TEASEL
Dipsacus fullonum
F: Caprifoliaceae
This stout biennial of rough ground in Europe, W. Asia, and N. Africa has prickly stems and leaves, and spiny flower bracts. Seeds are a winter food source for birds.

FUNGI

Ranging from mushrooms to microscopic moulds, fungi were once classified as plants. Today, they are recognized as a distinct kingdom of living things. Growing in or through their food, they digest organic matter, and often become visible only when they reproduce. Fungi are both allies and enemies to other forms of life: vital recyclers and mutually benefiting partners, they also include parasites and pathogens.

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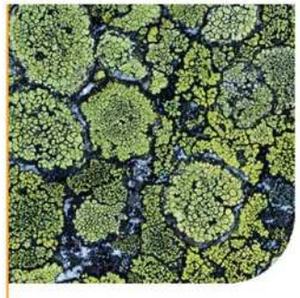
MUSHROOMS

As well as mushrooms, this large group includes bracket fungi, puffballs, and many other species. Their fruitbodies vary in shape, but all make their spores on microscopic cells called basidia.

» 238

SAC FUNGI

These fungi produce their spores in microscopic sacs, which often form a felty layer on their fruitbodies. Many are cup-shaped, but they also include truffles, morels, and single-celled yeasts.



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LICHENS

Living partnerships between fungi and algae, lichens colonize all kinds of bare surfaces. Some form flat crusts, while others are like tiny plants. Most grow slowly, and are exceptionally long-lived.

MUSHROOMS

The phylum Basidiomycota includes the majority of what are commonly called mushrooms and toadstools. Found in almost every major habitat type, nearly all share the ability to form sexual spores externally on special cells called basidia.

PHYLUM	BASIDIOMYCOTA
CLASSES	16
ORDERS	52
FAMILIES	177
SPECIES	About 32,000

These typical mushrooms show the cap with radiating gills on the underside, supported by the central stem.

The microscopic spores of the field mushroom are here shown still attached to the basidia, or reproductive cells.

This stinkhorn is covered with a dark spore mass, which rapidly liquifies and emits a foul odour, usually of rotting flesh.

DEBATE

COLOURFUL MYSTERY

Many mushrooms have bright colours: red, violet, blue, and green. Scientists have little idea what advantage these colours give to the mushroom. Unlike flowers, they do not need bright colours to attract pollinators. Red and orange pigments possibly prevent damage from sunlight, while others may act as a warning to predators.

Few fungi are as diverse in form as the Basidiomycota. Their fruitbodies (the structures in which spores are produced) have evolved to provide varied and efficient mechanisms for spore dispersal. These fruitbodies often take the form of a stem, cap, and gills, but many are simple, crust-like sheets, and others are more complex, bracket-like forms. More exotic still are the totally enclosed, spherical types such as the puffballs and the earthstars. Then there are the beautiful, coral-like structures of the club and coral fungi, and the often weird, animal-like shapes of the stinkhorns. Each structure supports and produces special spore-producing cells called basidia, and – depending on the fungus concerned – uses a variety of mechanisms to disperse these spores. For example, gilled fungi forcibly eject their spores, to be carried off by air currents. The puffballs, however, depend on a combination of wind and raindrops to puff out their spores. Stinkhorns, on the other hand, use foul odours and bright colours to attract animals, such as insects and other invertebrates, to eat their spore mass and to pass the spores unharmed through their digestive tracts. In this way the spores are scattered as far as the animals travel before excreting them.

FUNGAL FEEDING

The main body of the fungus is usually underground, formed of fine fungal threads called hyphae, which make up a mycelium (fungal body). These threads permeate the substance on which the fungus grows, be it soil, old leaf litter, fallen timber, living plant tissues, or even dead and decaying animals. The mycelium may spread over a large area, and in many fungi it also forms a mutually beneficial relationship with the roots of plants. In this relationship – called a mycorrhiza – the mycelium wraps around and penetrates the plant's roots, providing the fungus with access to carbohydrates from the plant. In return, the plant gains from the mycelium's greater ability to absorb water and mineral nutrients. Other mushrooms break down dead organic matter, or devour living organisms for food – both processes help to renew the soil and to improve the growing conditions for other living things.

MUSHROOMS AMONG FALLEN LEAVES >
Many fungi feed on dead and decaying plant tissues and may spread in huge numbers where nutrients and moisture occur.

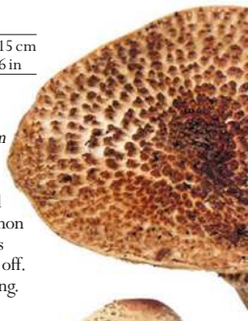
AGARICALES

Many of the most familiar mushrooms and toadstools belong to this order. They include fungi with fleshy, not woody, fruitbodies (the body supporting the spore-forming cells). Many have caps and stems with gills; some also have pores. Other forms include bird's-nest, brackets, crusts, truffle-like, and puffballs. Most live on leaf litter, soil, or wood; others are parasitic or live in association with plant roots (mycorrhizal).

FIELD MUSHROOM
Agaricus campestris
F: Agaricaceae
Common in meadows of Eurasia and N. America, this fungus has a rounded cap; bright pink gills turning brown with maturity; and a short stem with a small ring.

CULTIVATED MUSHROOM
Agaricus bisporus
F: Agaricaceae
Selling in millions, this familiar fungus is common worldwide. Its cap varies from white to dark brown with scales.

THE PRINCE
Agaricus augustus
F: Agaricaceae
A large, orange-brown, scaly cap and a white, woolly stem with a floppy ring characterize this common species from Eurasia and N. America.



FRECKLED DAPPERLING
Echinoderma asperum
F: Agaricaceae
From woods and gardens in Eurasia and N. America, this uncommon fungus's brown cap has pyramidal scales that rub off. The brown stem has a ring.

YELLOW STAINER
Agaricus xanthodermus
F: Agaricaceae
This species has a flattened cap centre, chrome-yellow stains on the stem base, and an unpleasant odour. It is common in Eurasia and western N. America.

HORSE MUSHROOM
Agaricus arvensis
F: Agaricaceae
Common in parks in Eurasia and N. America, this species stains dull brassy yellow. The pendent ring on its stem has a cogwheel-like pattern on its underside.

STINKING DAPPERLING
Lepiota cristata
F: Agaricaceae
A rubber-like smell is a characteristic feature of this species of *Lepiota* (most common in woods and meadows) from Eurasia and N. America.

ORANGE-GIRDLED DAPPERLING
Lepiota ignivolvata
F: Agaricaceae
Found in Eurasia, this uncommon species has an orange-margined ring set low down on the club-shaped, white stem.

LAWYER'S WIG
Coprinus comatus
F: Agaricaceae
This fungus is common on disturbed soils and pathsides in Eurasia and N. America. Its tall, shaggy cap is unmistakable, and dissolves into inky fluid.

BLUSHING DAPPERLING
Leucoagaricus badhamii
F: Agaricaceae
Found in Eurasia, this rare fungus grows in woods and gardens with rich soils. White when young, it bruises blood-red when handled, and then blackens.

SHAGGY PARASOL
Chlorophyllum rhacodes
F: Agaricaceae
Common in Eurasia and N. America, this fungus has a shaggy, brown cap; thick, double-edged ring; reddening flesh; and swollen stem base.

WHITE DAPPERLING
Leucoagaricus leucothites
F: Agaricaceae
Common in meadows and grassy roadsides in Eurasia and N. America, this fungus's ivory fruitbody turns grey-brown with age. Its gills are white to pale pink.

PLANTPOT DAPPERLING
Leucocoprinus birnbaumii
F: Agaricaceae
Common worldwide, this species grows on soils of potted plants. Its features include a delicate golden-yellow cap and a slender stem with a ring.

GREY PUFFBALL
Bovista plumbea
F: Agaricaceae
This ball-shaped fungus is smooth when young. As it matures, its skin flakes to reveal a papery inner layer. It is common in Eurasia and N. America.

GIANT PUFFBALL
Calvatia gigantea
F: Agaricaceae
Common in hedgerows, fields, and gardens in Eurasia and N. America, this mushroom's large, smooth, white fruitbody with a white to yellow interior is unmistakable.

PARASOL
Macrolepiota procera
F: Agaricaceae
Common in meadows in Eurasia and N. America, this tall species has a scaly cap and snakeskin-patterned stem with a thick ring.

STUMP PUFFBALL
Apioperdon pyriforme
F: Agaricaceae
Common in Eurasia and N. America, this pear-shaped species grows on wood. It has prominent cords at its base, and is firm when young.

WINTER STALKBALL
Tulostoma brumale
F: Agaricaceae
Typically found in sandy soils in dune slacks in Eurasia and N. America, this fungus has tiny, whitish yellow, round heads on slender, pale brown stalks.

SANDY STILTBALL
Battarreoides diguetii
F: Tulostomataceae
Found in very dry, sandy soils in N. America, this tall, stalked species emerges from a leathery "egg". Its brown cap contains the spores.

POPLAR FIELDCAP
Cyclocybe cylindracea
F: Bolbitiaceae
Found in Eurasia, this rare species grows on poplar wood. The cap cracks when dry and the stem has a ring.

MILKY CONECAP
Conocybe apala
F: Bolbitiaceae
This species is frequently found in lawns in Eurasia and N. America. Its conical, ivory cap with orange-brown gills sits on a tall stem.

COMMON FIELDCAP
Agrocybe pediades
F: Bolbitiaceae
Usually found in lawns in Eurasia, this fungus's smooth, yellowish cap and slender stem have a mealy smell and no veil.

SPRING FIELDCAP
Agrocybe praecox
F: Bolbitiaceae
Common in Eurasia and N. America during spring, this fungus's cap may have marginal veil fragments. The stem may have a fragile ring.

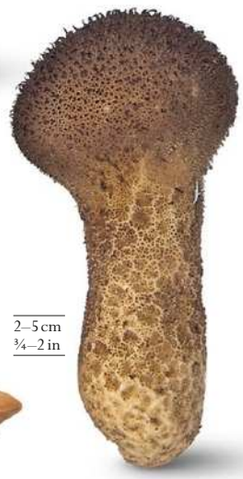
YELLOW FIELDCAP
Bolbitius titubans
F: Bolbitiaceae
Growing in meadows, this fungus is common in Eurasia and N. America. It has a delicate, sticky cap that lasts only a day or so.

MEADOW PUFFBALL
Lycoperdon pratense
F: Agaricaceae
This short-stemmed species has an internal membrane separating the spore-mass from the stem. It is common in meadows throughout Eurasia.

COMMON PUFFBALL
Lycoperdon perlatum
F: Agaricaceae
The most common white puffball, this species is found in Eurasia and N. America. Its granular spines rub off to leave circular scars in a regular pattern.

SPINY PUFFBALL
Lycoperdon echinatum
F: Agaricaceae
This species is found in beech woods in Eurasia and N. America. It has groups of long spines that meet at their tips. Its spores are purplish brown.

PESTLE PUFFBALL
Lycoperdon excipuliforme
F: Agaricaceae
One of the tallest puffballs, this fungus has a buff-white stem that is left behind once the spores are released. It is found in Eurasia.



STINKING PUFFBALL
Lycoperdon foetidum
F: Agaricaceae
Common in acidic heaths and woods in Eurasia, this yellowish brown puffball has dark brown spines. Its flesh has an unpleasant smell.

CAESAR'S MUSHROOM
Amanita caesarea
F: Amanitaceae

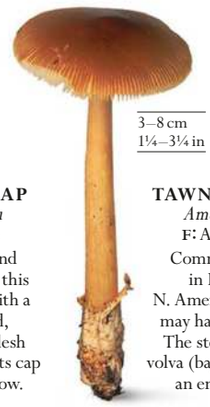
Found under oaks, mainly from the Mediterranean to C. Eurasia, this mushroom has an orange cap and stem, and a white volva.

DEATH CAP
Amanita phalloides
F: Amanitaceae

Common in Eurasia and parts of N. America, this species has a fragile ring, large volva, and sickly smell. Its cap may be greenish, yellowish, or white.

FALSE DEATHCAP
Amanita citrina
F: Amanitaceae

Found in Eurasia and eastern N. America, this species has a stem with a distinctly rimmed, rounded bulb, and flesh with a potato odour. Its cap is white or pale yellow.

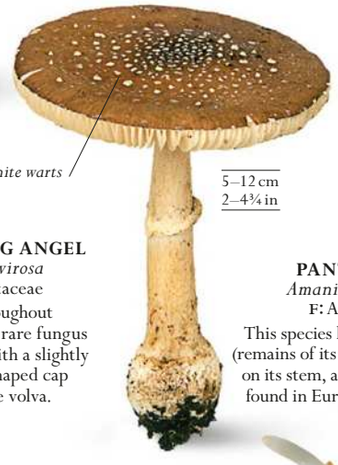


TAWNY GRISETTE
Amanita fulva
F: Amanitaceae

Common in woods in Eurasia and N. America, this fungus may have veil patches. The stem has a white volva (bag-like remains of an enclosing veil).

BLUSHER
Amanita rubescens
F: Amanitaceae

This species is common in mixed woods in Eurasia and N. America. Its cap varies from cream to brown, and its flesh bruises pinkish red.



DESTROYING ANGEL
Amanita virosa
F: Amanitaceae

Found throughout N. Eurasia, this rare fungus is pure white with a slightly sticky, bell-shaped cap and a white volva.

PANTHER CAP
Amanita pantherina
F: Amanitaceae

This species has pure white warts (remains of its protective veil), a ring on its stem, and a ridged bulb. It is found in Eurasia and N. America.

FLY AGARIC
Amanita muscaria
F: Amanitaceae

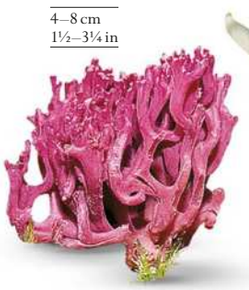
Common in Eurasia and N. America, this distinctive mushroom is especially common under birches. Its white warts may wash off after rain.

GOLDEN SPINDLES
Clavulinopsis corniculata
F: Clavariaceae

This golden-yellow club with antler-like branches is relatively common in acidic, unimproved meadows and grassy clearings in woods in Eurasia.

YELLOW CLUB
Clavulinopsis helvola
F: Clavariaceae

Common in grassland in Eurasia and N. America, this is one of several yellow clubs. It can only be reliably identified by its spiny spores.



VIOLET CORAL
Clavaria zollingeri
F: Clavariaceae

A rare species found in mossy meadows and woodlands in Eurasia and N. America, this species has violet, coral-like branches.

WHITE SPINDLES
Clavaria fragilis
F: Clavariaceae

This fungus forms dense clusters of pure white, simple clubs in woods and meadows in Eurasia.

WOOD PINKGILL
Entoloma rhodopolium
F: Entolomataceae

Found in Eurasia, this pale grey to grey-brown species has a cap with a domed centre and slender stem. It may smell of bleach.

MOUSEPEE PINKGILL
Entoloma incanum
F: Entolomataceae

Smelling of mice, this pinkgill has a hollow stem and a bright grass-green cap that fades to brown with age. It grows in unimproved meadows in Eurasia.

BLUE EDGE PINKGILL
Entoloma serrulatum
F: Entolomataceae

This blue-black capped fungus has serrated pinkish gills with dark edges. It is found in meadows and parks in Eurasia and N. America.

LILAC PINKGILL
Entoloma porphyrophaeum
F: Entolomataceae

Occasionally found in meadows, this fungus grows in Eurasia. It has a grey-purple fibrous cap and stem, and pinkish gills.

THE MILLER
Clitopilus prunulus
F: Entolomataceae

Common in mixed woods in Eurasia and N. America, this fungus has a cap that changes shape with age, starting convex then becoming depressed.

WOOD BLEWIT
Lepista nuda
F: Tricholomataceae
Common in mixed woods in Eurasia and N. America, this species has a violet cap that fades to brown, but the stem and gills remain violet.

BLUE LEGS
Lepista personata
F: Tricholomataceae
The blue legs has a buff cap and a bright blue-lilac stem with perfumed flesh. It is common in open meadows in Eurasia.

CLOUDED FUNNEL
Clitocybe nebularis
F: Tricholomataceae
This fleshy mushroom has crowded gills that often run down the stem. It frequently grows in large circles in Eurasia and N. America.

ANISEED FUNNEL
Clitocybe odora
F: Tricholomataceae
Common in Eurasia and N. America, this fungus is unmistakable due to its strong aniseed odour. Its sea-green colour fades as it matures to greyish green.

IVORY FUNNEL
Clitocybe dealbata
F: Tricholomataceae
This species grows in rings in lawns and meadows in Eurasia and N. America. It has a frosted appearance and slightly decurrent gills.

SULPHUR KNIGHT
Tricholoma sulphureum
F: Tricholomataceae
Characterized by its bright sulphur-yellow colour and repulsive smell of coal gas, this fungus is common in mixed woods in Eurasia and parts of N. America.

GIANT FUNNEL
Leucopaxillus giganteus
F: Tricholomataceae
Often found in huge fairy rings in Eurasia and N. America, this giant fungus is white, with decurrent gills, an inrolled cap margin, and a short stem.

DINGY AGARIC
Tricholoma portentosum
F: Tricholomataceae
Usually found with conifers in northern N. America and N. Eurasia, this species has a smooth, bell-shaped cap and a stout, whitish stem that flushes yellowish.

SOAPY KNIGHT
Tricholoma saponaceum
F: Tricholomataceae
Variable in colour – grey-brown, greenish or pinkish grey to mottled – with a soapy smell, this species is common in mixed woods in Eurasia and N. America.

PIPE CLUB
Typhula fistulosa
F: Typhulaceae
Often found in large groups in Eurasia and parts of N. America, this species has tall, slender clubs attached to fallen branches and hardwood litter.

FLY AGARIC

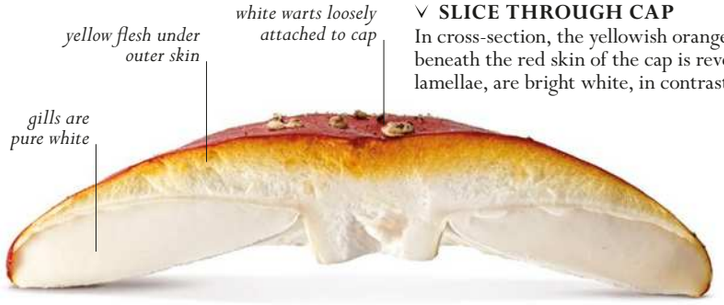
Amanita muscaria

The fly agaric is arguably the most famous of all fungi, and it appears in illustrations in children's books all over the world. The bright scarlet cap, usually scattered with white spots of veil tissue, make it one of the easiest fungi to identify. Found originally throughout most of Europe, northern Asia, and North America, it now grows wherever humans have planted the host trees – usually birch – with which the fungus forms a mutually beneficial relationship. It is now commonly found in parts of Africa, India, and Australasia. All parts of the fly agaric are poisonous, although rarely fatal.

SIZE Cap diameter 6–15 cm (2¼–6 in)
HABITAT Birch and pine woods
DISTRIBUTION Almost worldwide
SPORE COLOUR White

large floppy ring is easily torn

< FAMILIAR FUNGUS
The fly agaric changes shape dramatically as it grows and expands, but the colour and key characters usually remain constant. The cap may fade to yellow if there has been persistent rain. Its common name refers to an old folk remedy – the red skin of the cap was used in a saucer of milk to poison annoying house flies.



v SLICE THROUGH CAP
In cross-section, the yellowish orange flesh immediately beneath the red skin of the cap is revealed. The gills, or lamellae, are bright white, in contrast.

v SCALES
The white or pale yellow warty scales are all that remain of an enveloping veil of tissue that once enclosed the young cap.

STEM BASE >
The base is swollen and club-like, with warty ridges encircling the upper part of the bulb. Threads of mycelium (fungal tissue) connect to fine tree roots below the soil.

^ GILLS
The fly agaric's radiating gills are of different lengths, some stopping well short of the stem. This allows them to fill the available space, ensuring that spore production is maximized.

GROWTH STAGES OF A FLY AGARIC

^ BABY BUTTON
The young button is completely enclosed in a warty universal veil.

^ BROKEN VEIL
The stem has started to grow, and the universal veil on the cap has split apart.

^ GROWING CAP
The cap expands, with the partial veil still attached underneath.

^ GILLS APPEAR
The partial veil starts to tear, forming the ring and exposing the gills above.

^ SPORE DISPERSAL
Spores grow on the exposed gills and are then released into the air.

^ OLD AGE
At the end of its life the cap coloration fades and the cap may turn upwards.

5–12 cm
2–4¾ in

THE GYPSY
Cortinarius caperatus
F: Cortinariaceae
From N. Eurasia and N. America, this species, found in conifer woods, has a frosted cap with a white veil, and a stem with a distinct sheathing ring.

3–6 cm
1¼–2¼ in

DAPPLED WEBCAP
Cortinarius bolaris
F: Cortinariaceae
Frequent in beech woods in Eurasia, this fungus has tiny reddish brown scales on its cap and stem. The flesh stains yellow-orange in the stem.

5–8 cm
2–3¼ in

PEARLY WEBCAP
Cortinarius alboviolaceus
F: Cortinariaceae
This species is common in mixed woods in Eurasia and N. America. Its silvery white fruitbody has a lilac tint. The gills mature to cinnamon-brown.

6–10 cm
2¼–4 in

ELEGANT WEBCAP
Cortinarius elegantissimus
F: Cortinariaceae
Found throughout Eurasia in beech woods on chalky soil, this fungus has a vivid orange-yellow cap and a yellow stem with a large, marginate bulb.

5–10 cm
2–4 in

BLUE AND BUFF WEBCAP
Cortinarius malachius
F: Cortinariaceae
Found under pines in N. Eurasia, this uncommon species has a pale brown cap with a lilac tint, and a stem with bands of white veil.

raised point at cap centre

3–8 cm
1¼–3¼ in

SCALY WEBCAP
Cortinarius pholideus
F: Cortinariaceae
This uncommon species is found under birches in Eurasia. It is easily recognized by its scaly, brown cap and stem, and violet gills and stem apex when young.

scaly ring

6–10 cm
2¼–4 in

ORANGE WEBCAP
Cortinarius mucosus
F: Cortinariaceae
Restricted to N. Eurasia and N. America, this species is common in pine woods. Its orange-brown cap and stout, white stem are very slimy. The gills are rust-brown.

fine scales and fibres cover cap surface

5–12 cm
2–4¾ in

RED BANDED WEBCAP
Cortinarius armillatus
F: Cortinariaceae
The cinnabar-red bands of veil on the club-shaped stem distinguish this common species of birch woods in Eurasia and N. America.

6–10 cm
2¼–4 in

RED AND OLIVE WEBCAP
Cortinarius rufoolivaceus
F: Cortinariaceae
Found in beech woods throughout Eurasia, this uncommon species has a distinctively copper-coloured cap – with a pink or olive-green margin. The bulbous stem is violet to greenish yellow.

minute scales on cap

ring zone

6–15 cm
2¼–6 in

club-shaped stem

VIOLET WEBCAP
Cortinarius violaceus
F: Cortinariaceae
Found in mixed woodland throughout Eurasia and N. America, this rare species has a distinctive intensely violet-coloured cap and stem.

1–3 cm
⅜–1¼ in

4–10 cm
1½–4 in

BITTER BIGFOOT WEBCAP
Cortinarius sodagnitus
F: Cortinariaceae
Found mainly in S. England and Mediterranean Eurasia, this uncommon species occurs in beech woods on chalky soil. The bulb on the stem is large.

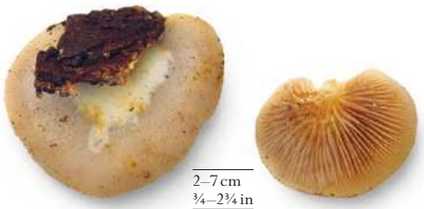
3–7 cm
1¼–2¾ in

SPLENDID WEBCAP
Cortinarius splendens
F: Cortinariaceae
This rare species has a golden-yellow cap, yellow flesh, a sulphur-yellow veil, and a bulbous stem. It mainly occurs in beech woods in Eurasia.

PIXIE WEBCAP
Cortinarius flexipes
F: Cortinariaceae
An odour of pelargoniums and delicate white hairs on the pointed cap characterize this species. It is common under birches in N. Eurasia and N. America.

8–15 cm
3¼–6 in

BIRCH WEBCAP
Cortinarius triumphans
F: Cortinariaceae
Common under birches in Eurasia, this fungus is yellow-orange overall, with prominent girdles of yellow veil on the stem.



2–7 cm
¾–2¾ in

CAP (UPPER SIDE) CAP (UNDERSIDE)

PEELING OYSTERLING
Crepidotus mollis
F: Crepidotaceae

This fungus occurs in Eurasia and N. America. Its small, fan-shaped, pale cap has a gelatinous skin, which peels easily. The stem is absent or very short.

VARIABLE OYSTERLING
Crepidotus variabilis
F: Crepidotaceae

One of several similar species in Eurasia and N. America, its cap is dry with fine fibres. It usually lacks a stem.

0.5–3 cm
3/16–1¼ in

0.3–0.8 cm
⅛–5/16 in

TINY PIXIE CAP
Galerina calyptrata
F: Hymenogastraceae

Found in Eurasia, this fungus is one of many species only identifiable under a microscope. Its rounded cap is orange-brown and striated.

CAP NOT FULLY EXPANDED

5–12 cm
2–4¾ in

ROOTING POISONPIE
Hebeloma radicosum
F: Hymenogastraceae

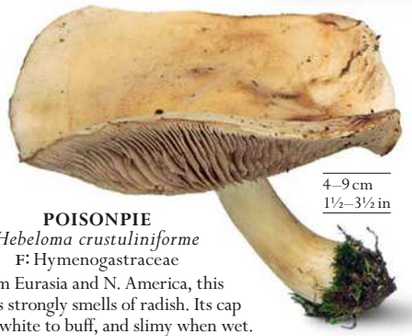
The deeply rooting stem with a large ring, buff cap with flat scales, and strong smell of marzipan characterize this Eurasian species.

attached to wood

1–5 cm
⅜–2 in

DEADLY GALERINA
Galerina marginata
F: Hymenogastraceae

This species has an orange-brown cap and a small ring on the stem. It grows on fallen timber in Eurasia and N. America.



4–9 cm
1½–3½ in

POISONPIE
Hebeloma crustuliniforme
F: Hymenogastraceae

From Eurasia and N. America, this species strongly smells of radish. Its cap is ivory-white to buff, and slimy when wet. In damp weather, the gills exude droplets.

3–7 cm
1¼–2¾ in

SPLIT FIBRECAP
Inocybe rimosa
F: Inocybaceae

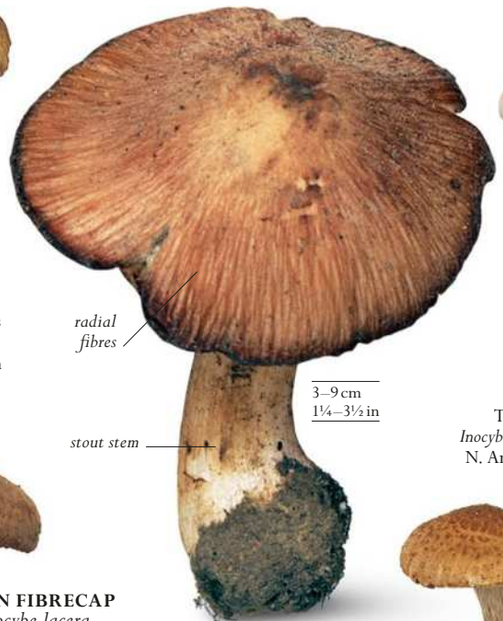
Common in mixed woodland in Eurasia and N. America, its pointed fibrous cap is straw-yellow and the stem is tall and slender.

red band

3–7 cm
1¼–2¾ in

STAR FIBRECAP
Inocybe asterospora
F: Inocybaceae

A flattened bulb at the stem's base and star-shaped spores distinguish this small, brown fibrous-capped species from Eurasia.



radial fibres

stout stem

3–9 cm
1¼–3½ in

DEADLY FIBRECAP
Inocybe erubescens
F: Inocybaceae

Found in mixed woodland on chalk in Eurasia, this uncommon species has a fibrous cap that discolours with age, and stout stem that bruises red.

WHITE FORM

1–4 cm
⅜–1½ in

WHITE FIBRECAP
Inocybe geophylla
F: Inocybaceae

This is one of the commonest *Inocybe* species in woods in Eurasia and N. America. It has a conical, silky cap and a slender stem.

VIOLET FORM

1–4.5 cm
⅜–1¾ in

TORN FIBRECAP
Inocybe lacera
F: Inocybaceae

Found in Eurasia and N. America, this fungus is distinguished by its cylindrical spores. It has a scaly fibrous cap and a slender brown stem.

0.8–4 cm
5/16–1½ in

LILAC LEG FIBRECAP
Inocybe griseolilacina
F: Inocybaceae

A common species of beech woods in Eurasia, it has a scaly cap and a pale violet, slender stem.

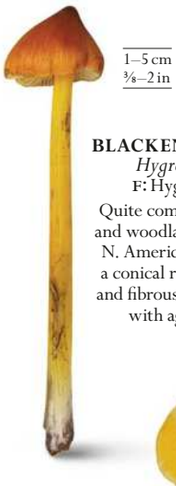
»

MEADOW WAXCAP
Cuphophyllus pratensis
F: Hygrophoraceae
One of the larger meadow waxcaps, it is found in Eurasia and N. America. It has a stout stem and a fleshy cap with gills running down the stem.

SNOWY WAXCAP
Cuphophyllus virgineus
F: Hygrophoraceae
The most common waxcap in all types of grassland in Eurasia, its waxy cap and slender stem are translucent. It has decurrent gills.

PARROT WAXCAP
Gliophorus psittacinus
F: Hygrophoraceae
This fungus occurs in Eurasia and N. America. Its slimy cap is vivid green to orange and the upper part of the stem is bright green.

PINK WAXCAP
Porpolomopsis calyptriformis
F: Hygrophoraceae
This highly recognizable but rare fungus has a pointed pink cap, fragile pale stem, and waxy gills. Found in Eurasia, it grows in unimproved meadows.



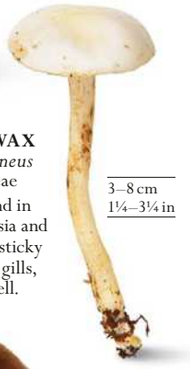
BLACKENING WAXCAP
Hygrocybe conica
F: Hygrophoraceae
Quite common in grasslands and woodlands in Eurasia and N. America, this species has a conical reddish orange cap and fibrous stem that blacken with age or bruising.

SCARLET WAXCAP
Hygrocybe coccinea
F: Hygrophoraceae
The scarlet, waxy cap, gills, and stem make this a very striking fungus of unimproved grasslands in Eurasia and N. America.

CRIMSON WAXCAP
Hygrocybe punicea
F: Hygrophoraceae
Found in unimproved grassland in Eurasia and N. America, this uncommon species is the largest blood-red waxcap. Its stem is dry and fibrous with a white base.

GOLDEN WAXCAP
Hygrocybe chlorophana
F: Hygrophoraceae
Found in Eurasia, this is the commonest waxcap found in meadows. It has a bright yellow-orange, slightly sticky cap.

CLUB FOOT
Ampulloclitocybe clavipes
F: Hygrophoraceae
Common in mixed woods in late autumn, this species from Eurasia and N. America has decurrent gills and a swollen, spongy base.



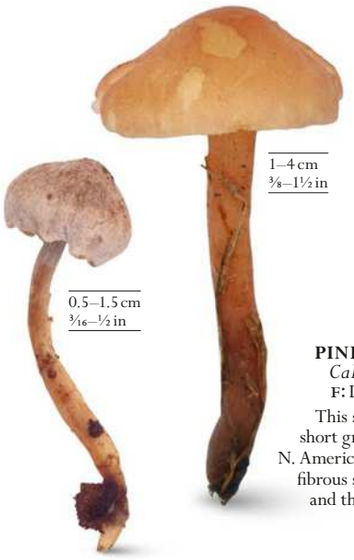
IVORY WOODWAX
Hygrophorus eburneus
F: Hygrophoraceae
This species is found in beech woods in Eurasia and N. America. It has a sticky cap and stem, thick gills, and a flowery smell.

AMETHYST DECEIVER
Laccaria amethystina
F: Hydnangiaceae
This highly recognizable, slender fungus from Eurasia and N. America has an intense violet coloration when fresh, and powdery spores dusting the gills.

DECEIVER
Laccaria laccata
F: Hydnangiaceae
Variable in colour – from brick-red to flesh-pink – with a dry cap and thick gills, this species is abundant in temperate woods in Eurasia and N. America.

CONIFERCONE CAP
Baeospora myosura
F: Cyphellaceae
Found in Eurasia and N. America, this is one of a few fungi growing mostly on pine cones. It has crowded, narrow gills and a velvety stem.

HERALD OF WINTER
Hygrophorus hypothejus
F: Hygrophoraceae
Appearing in pine woods after frost in Eurasia and N. America, this sticky fungus has an olive-brown cap and yellow stem.



ST GEORGE'S MUSHROOM
Calocybe gambosa
F: Lyophyllaceae

This ivory-buff species from Eurasia often grows in fairy rings at woodland margins in late spring. The mushroom smells strongly of newly ground meal.

PINK DOMECAP
Calocybe carnea
F: Lyophyllaceae

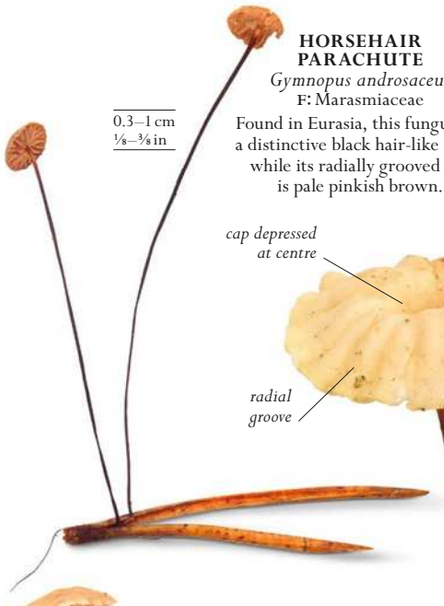
This species grows in short grass in Eurasia and N. America. Its smooth cap and fibrous stem are rose-pink and the gills are white.

SILKY PIGGYBACK
Asterophora parasitica
F: Lyophyllaceae

One of two well-known parasitic species to live on rotten fruitbodies of brittle-caps, this fungus from Eurasia and N. America has a rounded silky cap.

CLUSTERED DOMECAP
Lyophyllum decastes
F: Lyophyllaceae

Common on roadsides, pathsides, and disturbed soils in Eurasia and N. America, this fungus forms clumps of tough caps with stout stems.



HORSEHAIR PARACHUTE
Gymnopus androsaceus
F: Marasmiaceae

Found in Eurasia, this fungus has a distinctive black hair-like stem, while its radially grooved cap is pale pinkish brown.

FAIRY RING CHAMPIGNON
Marasmius oreades
F: Marasmiaceae

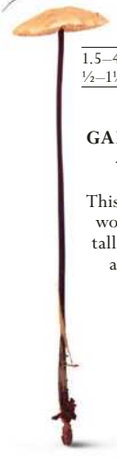
This classic fairy-ring mushroom is common in open grass in Eurasia and N. America. It has fleshy, beige caps with thick gills.

HAIRY PARACHUTE
Crinipellis scabella
F: Marasmiaceae

Found on dead stems of grasses, this recognizable fungus is from Eurasia. It has a small cap and a long, slender stem covered with dense, bristling brown hair.

COMMON BIRD'S NEST
Crucibulum laeve
F: Nidulariaceae

Forming miniature nests with spore-filled, egg-like cases, this common species may be hard to spot on woody debris. It occurs in Eurasia and N. America.



GARLIC PARACHUTE
Mycetinis alliaceus
F: Marasmiaceae

This species grows in beech woods in Eurasia. It has a tall, slender, blackish stem and a strong odour of rancid garlic.

COLLARED PARACHUTE
Marasmius rotula
F: Marasmiaceae

Like little parachutes, this mushroom's rounded, depressed caps are radially grooved. Its tough stems are attached to woody debris. It occurs in Eurasia and N. America.

FLUTED BIRD'S NEST
Cyathus striatus
F: Nidulariaceae

This fungus is recognized by its hairy, brown, and tall fluted nests containing 10–15 egg-like cases. It occurs on woody debris across Eurasia and N. America, but is not common.

» AGARICALES

SILVERLEAF FUNGUS
Chondrostereum purpureum
F: Cyphellaceae
Common on cherry and plum trees, this fungus is found in Eurasia and N. America. Violet below when young, it darkens to purple-brown with age.

2–5 cm
¾–2 in
wavy margin
purple underside

1–3 cm
⅜–1¼ in

SAFFRONDROP BONNET
Mycena crocata
F: Mycenaceae
Common in woods with chalky soils in Eurasia, this species exudes a bright saffron-orange juice when it is broken.

1–6 cm
⅜–2¼ in

COMMON BONNET
Mycena galericulata
F: Mycenaceae
Abundant in temperate woods in Eurasia and N. America, this fungus is variable in colour. Its pinkish grey gills have linking veins and cross-ridges.

0.3–1 cm
⅛–⅜ in

ORANGE BONNET
Mycena acicula
F: Mycenaceae
Common in leaf litter and debris in broadleaf woods in Eurasia and N. America, this fungus has a tiny, translucent cap that is striped almost to the centre.

0.5–2.5 cm
3/16–1 in

YELLOWLEG BONNET
Mycena epipterygia
F: Mycenaceae
Occurring in Eurasia and N. America, this fungus grows on acidic soils in woods and heaths. Its cap and stem have a sticky, peelable layer.

1–4 cm
⅜–1½ in

CLUSTERED BONNET
Mycena inclinata
F: Mycenaceae
Found in dense clusters on wood in Eurasia and N. America, this fungus has a cap with toothed margins and a strong soapy smell.

domed cap centre

ROSY BONNET
Mycena rosea
F: Mycenaceae
Found in beech woods in Eurasia, this common species has a robust pink cap and stem, and smells strongly of radish.

2–6 cm
¾–2¼ in

3–6 cm
1¼–2¼ in

BLACKEDGE BONNET
Mycena pelianthina
F: Mycenaceae
Found in Eurasia, this fungus is characterized by a strong smell of radish. It has purplish black-edged gills and a pale lilac to grey-brown cap.

OLIVE OYSTERLING
Sarcomyxa serotina
F: Mycenaceae
From Eurasia and N. America, this mushroom fruits in winter, often near water on hardwood tree trunks. Its cap is slimy when wet.

3–10 cm
1¼–4 in

club-shaped stem

4–8 cm
1½–3¼ in

SPINDLE TOUGHSHANK
Gymnopus fusipes
F: Omphalotaceae
Abundant in Eurasian oak woods from early summer onwards, this fungus forms large clumps of tough fruitbodies on tree roots.

2.5–6 cm
1–2¼ in

WOOD WOOLLYFOOT
Gymnopus peronatus
F: Omphalotaceae
The common name of this species from Eurasia refers to the stiff, fuzzy hairs at the base of the stem.

4–10 cm
1½–4 in

5–15 cm
2–6 in

3–6 cm
1¼–2¼ in

SPOTTED TOUGHSHANK
Rhodocollybia maculata
F: Omphalotaceae
Common in mixed woods across Eurasia and N. America, this fungus has a white cap, stem, and gills. The crowded gills stain rust-red with age.

BUTTER CAP
Rhodocollybia butyracea
F: Omphalotaceae
This fungus is abundant in woods in Eurasia and N. America. Varying from blackish or reddish brown to dark ochre, its cap is greasy to the touch.

JACK O'LANTERN
Omphalotus illudens
F: Omphalotaceae
Found across Eurasia and N. America, this bright orange, poisonous fungus is famous for gills that glow in the dark with an eerie greenish light.

3–10 cm
1¼–4 in

HONEY FUNGUS
Armillaria lutea
F: Physalacriaceae
Found in woods across Eurasia, this species is usually found on the ground. It is a weak parasite on the trees around which it grows.

2.5–10 cm
1–4 in

WRINKLED PEACH
Rhodotus palmatus
F: Physalacriaceae
Found on fallen logs of mainly elm, this uncommon species of Eurasia and N. America has an unusual, peach-pink, wrinkled cap and a fruity odour.

1–6 cm
⅜–2¼ in

VELVET SHANK
Flammulina velutipes
F: Physalacriaceae
Growing throughout winter in Eurasia and N. America, this fungus is characterized by its often sticky cap and velvety stem.

2–15 cm
¾–6 in

PORCELAIN FUNGUS
Mucidula mucida
F: Physalacriaceae
Usually found on beech logs in Eurasia, this fungus has grey-white caps that are slimy when wet. The tough stem has a thin ring.

2.5–10 cm
1–4 in

ROOTING SHANK
Hymenopellis radicata
F: Physalacriaceae
Found across Eurasia and N. America, this deep-rooted fungus has a stiff, tall stem. The cap is slimy when wet, and the gills are widely spaced.

BRANCHING OYSTER
Pleurotus cornucopiae
F: Pleurotaceae
Growing in clusters on fallen logs, usually of elm, this fungus has trumpet-shaped caps with gills running down the short, frequently branching stems. It occurs in Eurasia and N. America.

4–12 cm
1½–4¾ in

caps often overlap
6–20 cm
2¼–8 in

OYSTER MUSHROOM
Pleurotus ostreatus
F: Pleurotaceae
From Eurasia and N. America, this species is found on trees and logs. Its shelf-like caps vary from blue-green to pale buff. The stem is almost absent.

2–3 cm
¾–1¼ in

tiny glistening granules

GLISTENING INKCAP
Coprinellus micaceus
F: Psathyrellaceae
Usually found in clusters, this mushroom's rounded, grooved caps are dusted with mica-like flakes of veil. It is common on wood in Eurasia and N. America.

0.5–1 cm
3/16–⅜ in

FAIRIES' BONNETS
Coprinellus disseminatus
F: Psathyrellaceae
Often found in clusters on rotted stumps in Eurasia and N. America, it has tiny umbrella-like caps with deeply fluted grooves. The gills are blackish when mature.

2.5–7.5 cm
1–3 in

WEEPING WIDOW
Lacrymaria lacrymabunda
F: Psathyrellaceae
Common on pathsides and disturbed soils in Eurasia and N. America, it is named after its black gills that weep droplets from their edges.

white veil breaks into patches
5–8 cm
2–3¼ in

MAGPIE INKCAP
Coprinopsis picacea
F: Psathyrellaceae
Found on chalky soils in Eurasian woodlands, this uncommon species has white, fluffy scales that contrast with the dark grey-brown cap.

1.5–7 cm
½–2¾ in

PALE BRITTLESTEM
Psathyrella candolleana
F: Psathyrellaceae
Usually found in clusters on woody debris in early summer, this fungus has fragile, slender stems and pale or buff caps. It occurs in Eurasia and N. America.

0.8–4 cm
5/16–1½ in

CLUSTERED BRITTLESTEM
Psathyrella multipedata
F: Psathyrellaceae
The densely clustered stems of this species are joined at the base. It is usually found in open grass across Eurasia.

2.5–8 cm
1–3¼ in

COMMON INKCAP
Coprinopsis atramentaria
F: Psathyrellaceae
Occurring in Eurasia and N. America, this species has egg-shaped caps that dissolve to a blackish fluid as the spores are released.

»

» AGARICALES

4–10 cm
1½–4 in

DEER SHIELD
Pluteus cervinus
F: Pluteaceae

Found in Eurasia and N. America, this species is variable in colour, with a radially fibrous cap, often dome-centred; pink gills not attached to the stem; and a fibrous stem.

1–6 cm
⅜–2¼ in

YELLOW SHIELD
Pluteus chrysophlebius
F: Pluteaceae

A golden to greenish yellow cap, yellow gills turning pink, and a whitish stem characterize this species. Found in Eurasia, it grows on decayed wood.

2.5–8 cm
1–3¼ in

WILLOW SHIELD
Pluteus salicinus
F: Pluteaceae

Common in broadleafed woodlands in Eurasia, this species can be identified by the bluish grey staining at the base of its slender stem.

10–25 cm
4–10 in

BEEFSTEAK FUNGUS
Fistulina hepatica
F: Schizophyllaceae

Resembling a fleshy steak, with blood-like red juice, this species is particularly common in warmer parts of Eurasia and N. America.

fine silky-hairy surface

10–25 cm
4–10 in

SILKY ROSEGILL
Volvariella bombycina
F: Pluteaceae

Growing on deciduous trees in Eurasia and N. America, this rare species has a white to pale lemon cap and a whitish stem with a bag-like thin veil enclosing the base of the stem.

1–5 cm
⅜–2 in

CAP (UNDERSIDE)

CAP (UPPER SIDE)

COMMON PORECRUST
Schizophyllum commune
F: Schizophyllaceae

Found in Eurasia and N. America, this fan-shaped fungus is identified by the gill-like spore surface on the underside of the cap.

greenish yellow gills

orange cap centre

6–14 cm
2¼–5½ in

STUBBLE ROSEGILL
Volvopluteus gloiocephalus
F: Pluteaceae

Quite common in fields and old stubble, and on woodchip mulch, in Eurasia and N. America, this species has a sticky, grey cap.

3–7 cm
1¼–2¾ in

CONIFER TUFT
Hypholoma capnoides
F: Strophariaceae

Found in Eurasia and N. America, this uncommon species occurs on conifer wood. Its whitish gills mature to greyish lilac.

3–7 cm
1¼–2¾ in

SULPHUR TUFT
Hypholoma fasciculare
F: Strophariaceae

Abundant in temperate woods in Eurasia and N. America, this species has greenish yellow gills that mature to dark purple, and are easy to recognize in the field.

5–10 cm
2–4 in

BRICK TUFT
Hypholoma lateritium
F: Strophariaceae

This species is characterized by a fleshy cap with veil fragments and pale yellow gills that mature to lavender. It grows on hardwoods in Eurasia and N. America.

SHEATHED WOODTUFT
Kuehneromyces mutabilis
F: Strophariaceae
Often confused with the deadly *Galerina marginata*, this species can be identified by its sticky cap, scaly stem, and brown gills. It occurs in Eurasia and N. America.

REDLEAD ROUNDHEAD
Leratiomyces ceres
F: Strophariaceae
Previously known as *Stropharia aurantiaca*, this species has a bright red cap and reddish flushed stem. It grows among woodchips in Eurasia and N. America.

ALDER SCALYCAP
Pholiota alnicola
F: Strophariaceae
Found in Eurasia, this species is characterized by a sticky cap and tufted habit. Despite its common name, it is usually seen at the base of birches.

GOLDEN SCALYCAP
Pholiota aurivella
F: Strophariaceae
This rather common species is found on beech logs or trunks in Eurasia and N. America. Its sticky golden caps have dark orange-brown scales.

SHAGGY SCALYCAP
Pholiota squarrosa
F: Strophariaceae
Growing in Eurasia and N. America, this fungus has a distinctive dry, sharply scaly cap and stem; pale yellow gills; and a smell of corn or radish.

DUNG ROUNDHEAD
Protostropharia semiglobata
F: Strophariaceae
Occurring on animal dung or in grass where animals graze, this species is found in Eurasia and N. America. It has a sticky cap and a slender stem with a ring.

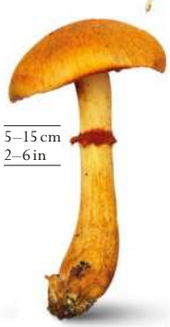
LIBERTY CAP
Psilocybe semilanceata
F: Strophariaceae
This well-known agaric has a conical, dull yellow cap with a distinct point. Common in meadows in late autumn, it occurs in Eurasia and N.America.

BLUE-GREEN SLIMEHEAD
Stropharia cyanea
F: Strophariaceae
This fungus has a blue-green cap that fades to yellow. It is found in Eurasia and N. America.

WHITELACED SHANK
Megacollybia platyphylla
F: Incertae sedis
Found in Eurasia and N. America, this species has a radially fibrous, pale grey-brown cap; widely spaced, deep gills; and a stem base with root-like strands.

COMMON CAVALIER
Melanoleuca polioleuca
F: Incertae sedis
Common in grass in Eurasia, this species has a grey-brown cap with white gills. Its stem has blackish flesh at the base.

PLUMS AND CUSTARD
Tricholomopsis rutilans
F: Incertae sedis
Common on pine stumps, this species has a reddish purple cap and stem, and golden-yellow gills. It grows in Eurasia and N. America.



SPECTACULAR RUSTGILL
Gymnopilus junonius
F: Incertae sedis
Occurring in Eurasia, this fungus is found in clumps, usually at the base of a tree. It has a dry cap with crowded, shallow yellowish gills.

PETTICOAT MOTTLEGILL
Panaeolus papilionaceus
F: Incertae sedis
The minute toothed remains of the veil at the cap margin and mottled black gills characterize this species. It is found in Eurasia and N. America.

GOBLET
Pseudoclitocybe cyathiformis
F: Incertae sedis
This distinctive species has a very dark coloration and a tall, fibrous stem. Found in Eurasia, it is common in late autumn and winter.

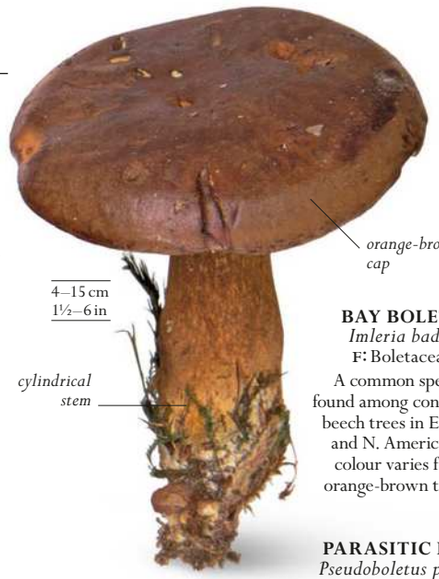
EGGHEAD MOTTLEGILL
Panaeolus semiovatus
F: Incertae sedis
Found on animal dung, this species occurs in Eurasia and N. America. It is characterized by a sticky grey cap and a ring around its tall stem.

TROOPING FUNNEL
Infundibulicybe geotropa
F: Incertae sedis
This fungus has a funnel-shaped, fleshy cap; a tall stem; and pale leather-brown colouring. It occurs in Eurasia.

CINNABAR POWDERCAP
Cystodermella cinnabarina
F: Incertae sedis
Found in Eurasia and N. America, this species has a brick-red cap and pale cream gills. The cap and stem have a granular surface.

BOLETALES

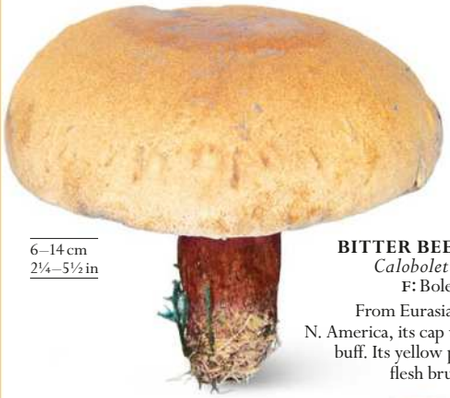
This order contains fleshy fungi and includes those with both pored and gilled fruitbodies, most with cap and stem, but some are crusts, puffballs, or truffle-like. The majority live in association with trees (mycorrhizal), but some feed on dead wood and cause a brown rot, while others are parasitic. The spore-producing layer – the hymenium – is easily loosened from the flesh.



BAY BOLETE
Imleria badia
F: Boletaceae
A common species found among conifers or beech trees in Eurasia and N. America, its colour varies from orange-brown to bay.

PENNY BUN
Boletus edulis
F: Boletaceae
Found worldwide, this species has fine white markings on its stem, unchanging cream flesh, and white pores that mature to yellow.

SUMMER BOLETE
Boletus reticulatus
F: Boletaceae
A cracking, matt, brown cap and a stem with a fine white net extending to its base distinguish this species from Eurasia and eastern N. America.



BITTER BEECH BOLETE
Caloboletus calopus
F: Boletaceae
From Eurasia and western N. America, its cap varies from white to buff. Its yellow pores and cream flesh bruise blue.

PARASITIC BOLETE
Pseudoboletus parasiticus
F: Boletaceae
This small mushroom from Eurasia and N. America grows only on the common earthball, causing its host to become hollow.

PEPPERY BOLETE
Chalciporus piperatus
F: Boletaceae
Common under conifers and also found with fly agaric under birches in Eurasia and N. America, it has cinnamon pores and yellow flesh.

BITTER BOLETE
Tylopilus felleus
F: Boletaceae
This species, found in Eurasia and N. America, is characterized by pores that turn pink with age and a strongly netted stem.

OLD MAN OF THE WOODS
Strobilomyces strobilaceus
F: Boletaceae
Found in Eurasia and N. America, this rare species is unmistakable with black woolly scales on its cap and stem, and white tubes.

8–15 cm
3¼–6 in

ORANGE BIRCH BOLETE
Leccinum versipelle
F: Boletaceae
Found in Eurasia, this species has a yellow-orange fleshy cap. The stem has black, woolly flecks and the flesh stains lilac-black.

6–15 cm
2¼–6 in

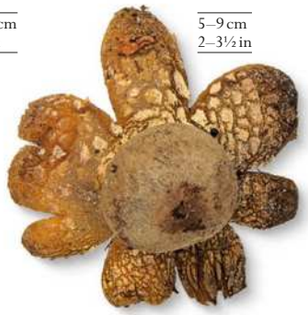
BROWN BIRCH BOLETE
Leccinum scabrum
F: Boletaceae
One of many similar species, this fungus is from Eurasia and N. America. Its flesh may flush pink when cut, and the cap is sticky when wet.

1–2 cm
⅜–¾ in

STALKED PUFFBALL-IN-ASPIC
Calostoma cinnabarinum
F: Calostomataceae
From N. America, this species' bright cinnabar-red ball on a stem emerges from a gelatinous layer.

5–100 cm
2–39 in

WET ROT
Coniophora puteana
F: Coniophoraceae
Found worldwide, this fungus forms a brown sheet of tissue, often warty or wrinkled, on wet timber. It causes serious damage to buildings.


5–9 cm
2–3½ in

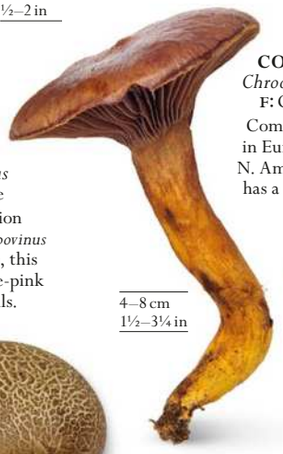
BAROMETER EARTHSTAR
Astraeus hygrometricus
F: Diplocystidiaceae
Frequent in Eurasia and N. America, this species' star-like arms peel back to reveal the inner spore-filled ball, but close again in dry weather.

5–8 cm
2–3¼ in

CORNFLOWER BOLETE
Gyroporus cyanescens
F: Gyroporaceae
Growing on acidic soils in Eurasia and eastern N. America, this uncommon species is distinguished by its brittle, hollow stem.

1.5–5 cm
½–2 in

ROSY SPIKE
Gomphidius roseus
F: Gomphidiaceae
Growing in association with the bolete *Suillus bovinus* under pines in Eurasia, this fungus has a slimy, rose-pink cap with greyish gills.


4–8 cm
1½–3¼ in

COPPER SPIKE
Chroogomphus rutilus
F: Gomphidiaceae
Common under pines in Eurasia and western N. America, this species has a pointed, coppery brown cap.

6–15 cm
2¼–6 in

BROWN ROLLRIM
Paxillus involutus
F: Paxillaceae
Common in mixed woods in Eurasia and N. America, the downy, inrolled cap margin and soft yellow gills staining brown characterize this species.

2–8 cm
¾–3¼ in

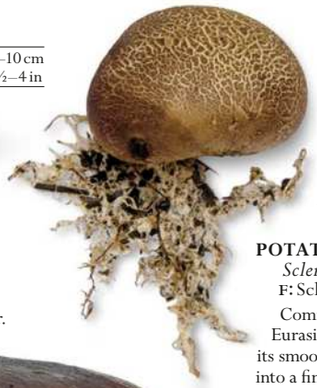
FALSE CHANTERELLE
Hygrophoropsis aurantiaca
F: Hygrophoropsidaceae
Sometimes mistaken for a chanterelle, this species from Eurasia and N. America is distinguished by its crowded, multi-forked, soft gills.

10–30 cm
4–12 in

VELVET ROLLRIM
Tapinella atrotomentosa
F: Tapinellaceae
Common on pine stumps in Eurasia and N. America, it has a cap with an inrolled margin; soft, thick gills; and a velvety stem.

4–10 cm
1½–4 in

COMMON EARTHBALL
Scleroderma citrinum
F: Sclerodermataceae
This potato-like fungus is common in damp woodland in Eurasia and N. America. Its thick skin has dark scales and a spore-filled black interior.


2–5 cm
¾–2 in

POTATO EARTHBALL
Scleroderma bovista
F: Sclerodermataceae
Common in woods in Eurasia and N. America, its smooth outer skin cracks into a fine mosaic. The inner purple-black spore-mass dries brownish.

5–10 cm
2–4 in

DYEBALL
Pisolithus arhizus
F: Sclerodermataceae
This species is found worldwide on poor, sandy soils associated with pines. The egg-like spore-sacs in its interior are embedded in blackish jelly.

cap skin peels off
4–10 cm
1½–4 in
dots can weep milky latex

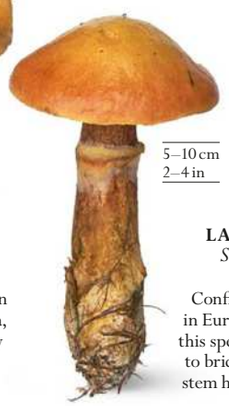
WEEPING BOLETE
Suillus granulatus
F: Suillaceae
Common under pines in Eurasia and N. America, its ringless stem is covered with glandular dots.

5–10 cm
2–4 in

SLIPPERY JACK
Suillus luteus
F: Suillaceae
Found on pines in Eurasia and N. America, this fungus has a slimy cap and yellow pores. The large ring on its stem has a lavender underside.

3–7 cm
1¼–2¾ in

BOVINE BOLETE
Suillus bovinus
F: Suillaceae
Common under pines in Eurasia and N. America, this species has a sticky cap and angular, irregular pores.


5–10 cm
2–4 in

LARCH BOLETE
Suillus grevillei
F: Suillaceae
Confined to larch woods in Eurasia and N. America, this species is yellow-orange to brick-red in colour. The stem has an ascending ring.

yellow-brown cap surface is dry and rough
7–13 cm
2¾–5 in

VELVET BOLETE
Suillus variegatus
F: Suillaceae
Frequent under pines in Eurasia, this species has a felty-scaly cap, with dark cinnamon-brown pores, and a ringless stem.

CANTHARELLALES

The species of the Cantharellales order may look like agarics (members of the Agaricales order), but differ in several important respects. They may have fleshy fruitbodies with a cap and stem, but they lack true gills, having instead a smooth, wrinkled, or folded gill-like spore-producing surface on the underside. The spores are smooth and usually white to cream.

3–8 cm
1¼–3¼ in

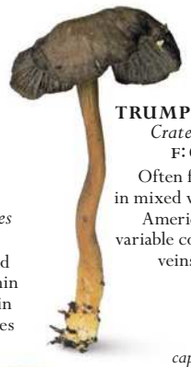
CRESTED CORAL
Clavulina coralloides
F: Clavulinaceae

Very common in woods in Eurasia and N. America, this fungus forms a coral-like mass of white branches, each dividing into fine points.

0.5–2 cm
3/16–¾ in

HORN OF PLENTY
Craterellus cornucopioides
F: Cantharellaceae

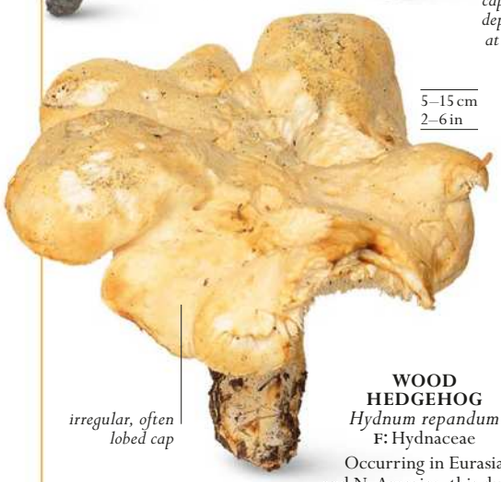
A distinctive species found throughout Eurasia, this thin trumpet grows in troops in beech leaf litter. It produces a white spore deposit.



1–6 cm
⅜–2¼ in

TRUMPET CHANTERELLE
Craterellus tubaeformis
F: Cantharellaceae

Often found in large troops in mixed woods in Eurasia and N. America, this fungus has a variable colour and shallow, blunt veins rather than gills.



5–15 cm
2–6 in

irregular, often lobed cap

WOOD HEDGEHOG
Hydnum repandum
F: Hydnaceae

Occurring in Eurasia and N. America, this dusky orange species is irregular in shape, with tiny spines underneath the cap.

cap often depressed at centre

inrolled margin

2–12 cm
¾–4¾ in

CHANTERELLE
Cantharellus cibarius
F: Cantharellaceae

Found in Eurasia and N. America, this species has blunt-edged gills with numerous cross-veins and a smell of apricots.

tapered stem

GEASTRALES

The Geastrales, or earthstars, share the common character of a thick outer layer – the peridium – which splits apart and peels back to form star-like arms. These reveal a central spore-sac, like a puffball, from which the dark brown, warted spores exit via a pore at the apex. Earthstars are found in leaf litter and bare, sandy soils – for example, in sand dunes.

STRIATE EARTHSTAR
Geastrum striatum
F: Geastraceae

Found in Eurasia, this is one of the smaller earthstars. Its pale grey spore-sac is stalked and has a sharply pointed, striated opening.

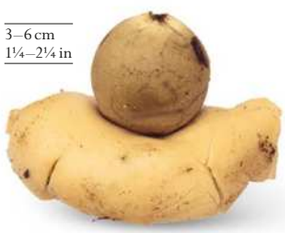
3–6.5 cm
1¼–2½ in

collar below spore-sac

4–12 cm
1½–4¾ in

COLLARED EARTHSTAR
Geastrum triplex
F: Geastraceae

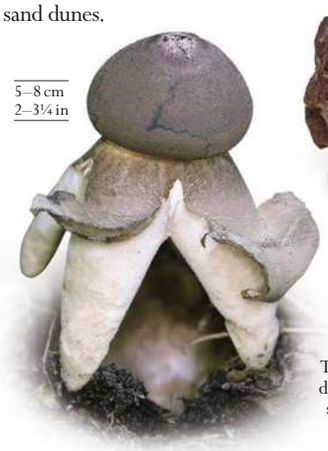
Growing in Eurasia and N. America, this is the most common earthstar. Its rays crack to leave a cup-like collar around the spore-sac.



3–6 cm
1¼–2¼ in

SESSILE EARTHSTAR
Geastrum fimbriatum
F: Geastraceae

Found in Eurasia and N. America, this fungus's globe-shaped, pale brown fruitbody splits open with 5–9 arms. Its greyish spore-sac has a fringed opening.



5–8 cm
2–3¼ in

ARCHED EARTHSTAR
Geastrum fornicatum
F: Geastraceae

This earthstar's arms stay attached to a disc of tissue on the soil, and its stalked spore-sac has a prominent opening. It occurs in Eurasia and N. America.

7–15 cm
2¾–6 in

PEPPER POT
Myriostoma coliforme
F: Geastraceae

Found on dry, sandy soils in Eurasia and N. America, this rare species has a distinctive, large spore-sac with several pore openings.

GOMPHALES

Although some species were included with the chanterelles in Cantharellales, DNA analysis of the Gomphales fungi suggests that they are more closely related to the stinkhorn fungi in the Phallales. They often form large fruitbodies, varying in shape from simple clubs (in genus *Clavariadelphus*) to trumpet- or chanterelle-like structures with a complex spore-producing surface (in genus *Gomphus*).

2–6 cm
¾–2¼ in

GIANT CLUB
Clavariadelphus pistillaris
F: Clavariadelphaceae
A rare species of Eurasia and N. America, this fungus forms a large, swollen club, with a smooth to slightly wrinkled surface, which bruises purple-brown.

5–10 cm
2–4 in

SCALY VASE CHANTERELLE
Gomphus floccosus
F: Gomphaceae
Common in N. America, this fungus resembles a fleshy, trumpet-shaped vase with scales at the top and wrinkled "gills" on its undersurface.

3–8 cm
1¼–3¼ in

UPRIGHT CORAL
Ramaria stricta
F: Gomphaceae
A fairly common species in Eurasia and N. America, it is always attached to decaying wood or woodchip mulch. The branches are pale brown, bruising reddish.

7–15 cm
2¾–6 in

ROSSO CORAL
Ramaria botrytis
F: Gomphaceae
Found in beech woods in Eurasia and N. America, this uncommon coral fungus has pinkish white branches with deep red tips.

1.5–4 cm
½–1½ in

GREENING CORAL
Phaeoclavulina abietina
F: Gomphaceae
Found in conifer woods in Eurasia and N. America, this yellow-olive fungus has densely packed branches that bruise green.

GLOEOPHYLLALES

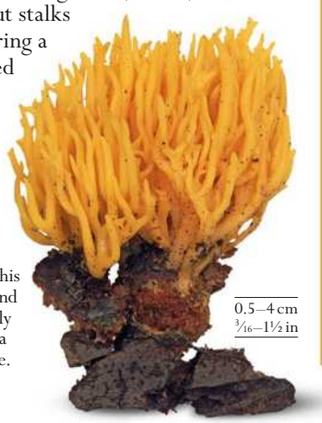
This is an order of wood-decay fungi that is characterized by the ability to produce a brown rot of wood. The order Gloeophyllales has a single family, the Gloeophyllaceae, which includes the genus *Gloeophyllum*. Some well-known bracket fungi on conifer timber are members of this genus.

5–20 cm
2–8 in

ANISE MAZEGILL
Gloeophyllum odoratum
F: Gloeophyllaceae
This fungus, which grows on decayed conifer wood, is found in Eurasia and N. America. It has irregular brackets with yellow pores and an aniseed odour.

DACRYMYCETALES

This order forms very simple, rounded or branched gelatinous fruitbodies, usually with bright orange coloration. Smooth or wrinkled, the Dacrymycetales have unusual spore-producing cells (basidia), which typically have two stout stalks (sterigmata), each bearing a spore. They mainly feed on dead wood.



0.5–4 cm
3/16–1½ in

YELLOW STAGSHORN
Calocera viscosa
F: Dacrymycetaceae
Attached to conifer wood, this fungus is found in Eurasia and N. America. Its clubs usually divide into branches with a gelatinous, rubbery texture.

HYMENOCHAETALES

This group contains a number of diverse types of fungi including some crust fungi, polypores, such as *Mensularia* and *Phellinus*, as well as several agaric species, such as *Rickenella*. The Hymenochaetales are defined through molecular studies and have few uniting physical characteristics. Many feed on wood and may cause a white rot of timber.

1–6 cm
⅜–2¼ in

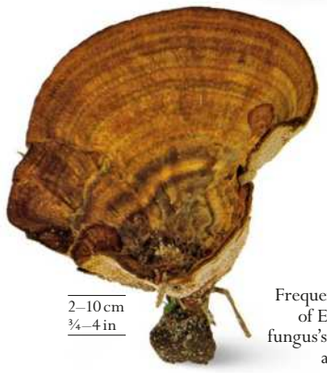
OAK CURTAIN CRUST
Hymenochaete rubiginosa
F: Hymenochaetaceae
Found across Eurasia, this fungus forms overlapping brackets and crusts mainly on fallen oak timber. Its tough fruitbodies have concentric markings.

10–40 cm
4–16 in

WILLOW BRACKET
Phellinus igniarius
F: Hymenochaetaceae
This grey to almost black perennial bracket from Eurasia and N. America grows over many years. It is hoof-shaped and extremely woody.

3–8 cm
1¼–3¼ in

ALDER BRACKET
Mensularia radiata
F: Hymenochaetaceae
This deep reddish brown fungus with a paler margin often forms vertical chains of brackets on alder and other trees in Eurasia and N. America.



2–10 cm
¾–4 in

TIGER'S EYE
Coltricia perennis
F: Hymenochaetaceae
Frequently found in acidic heathlands of Eurasia and N. America, this fungus's goblet-shaped, thin fruitbodies are concentrically zoned.

0.3–1 cm
⅛–⅜ in

ORANGE MOSSCAP
Rickenella fibula
F: Incertae sedis in Rickenella clade
This tiny species is common in mossy grasslands of Eurasia and N. America. Its bright orange cap is radially marked with a darker centre.

POLYPORALES

The Polyporales form a large group of diverse fungi. Most of these are polypores – wood decomposers whose spores are formed in tubes (rather like the tubes of the boletes) or sometimes on spines. Most lack fully developed stems and grow shelf-, bracket-, or crust-like fruitbodies on wood, but some have more or less central stems and grow at the base of trees. A few Polyporales appear to grow from the soil.

RED BELTED POLYPORE
Fomitopsis pinicola
F: Fomitopsidaceae
Occurring in Eurasia and N. America, this hoof-shaped, woody bracket is usually found on pines, and sometimes on birches.

OAK MAZEGILL
Daedalea quercina
F: Fomitopsidaceae
Found on fallen oaks in Eurasia and N. America, this perennial species has tough brackets with long maze-like pores on the underside.

DYER'S MAZEGILL
Phaeolus schweinitzii
F: Fomitopsidaceae
Usually found at the base of conifers in Eurasia and N. America, this large, furry, cushion-like bracket is used for the manufacture of dye.

10–50 cm
4–20 in

RAZORSTROP FUNGUS
Fomitopsis betulinas
F: Fomitopsidaceae
This large, kidney-shaped bracket is pale brown to white. A damaging parasite of birches, it is found in Eurasia and N. America.

CHICKEN OF THE WOODS
Laetiporus sulphureus
F: Fomitopsidaceae
These large brackets, found in Eurasia and N. America, usually grow on oaks and sometimes on other trees.

ARTIST'S BRACKET
Ganoderma applanatum
F: Ganodermataceae
Found in Eurasia and N. America, this woody perennial bracket grows for many years to reach huge sizes. Its fallen spores are a rich cinnamon-brown.

LACQUERED BRACKET
Ganoderma lucidum
F: Ganodermataceae
This deep reddish to purple-brown bracket with a shiny surface may have a long, lateral stem. It is found in Eurasia and N. America.

GIANT POLYPORE
Meripilus giganteus
F: Meripilaceae
One of the largest polypores, its overlapping brackets are thick and fleshy. It grows around beech and other trees in Eurasia and N. America.

ZONED ROSETTE
Podoscypha multizonata
F: Meruliaceae
Growing on soil from buried oak roots, this rare species occurs in Eurasia. It has densely packed lobes that form a circular mass.

JELLY ROT
Phlebia tremellosa
F: Meruliaceae
Found on logs in Eurasia, this species has a pale, velvety upper side and a yellow-to-orange underside with dense ridges.

SMOKY BRACKET
Bjerkandera adusta
F: Meruliaceae
This common bracket, found in Eurasia and N. America, can be identified by the ash-grey pore surface on its underside.

5–30 cm
2–12 in

TINDER BRACKET
Fomes fomentarius
F: Polyporaceae

This grey-brown, hoof-shaped, perennial bracket grows on birches and other deciduous trees. It is found in Eurasia and N. America.

8–15 cm
3¼–6 in

BLUSHING BRACKET
Daedaleopsis confragosa
F: Polyporaceae

One of the commonest brackets, especially on willows, in Eurasia and N. America, this semicircular species has cream pores that bruise pinkish red.

BIRCH MAZEGILL
Lenzites betulina
F: Polyporaceae

Usually found on birches in Eurasia and N. America, this tough, leathery species has pores that can be extremely elongated in gill-like ridges.

3–10 cm
1¼–4 in

UPPER SURFACE

UNDERSIDE

10–60 cm
4–23½ in

DRYAD'S SADDLE
Cerioporus squamosus
F: Polyporaceae

Found in early summer in Eurasia and N. America, these circular or fan-shaped brackets have concentric scales and pores on the underside.

funnel-shaped cap

5–20 cm
2–8 in

velvety stem base

BLACK FOOTED POLYPORE
Polyporus durus
F: Polyporaceae

This fungus has a funnel-shaped, leathery cap and its stem is black at the base. It grows on fallen beech logs in Eurasia and N. America.

5–20 cm
2–8 in

TUBEROUS POLYPORE
Polyporus tuberaster
F: Polyporaceae

Growing on fallen branches in Eurasia and N. America, this species may root into the ground and form a large, tuberous mass.

3–8 cm
1¼–3¼ in

WINTER POLYPORE
Lentinus brumalis
F: Polyporaceae

This small species grows on fallen branches in Eurasia and N. America. It has rather large, decurrent (running down the stem) pores. The stem is central or off-centre.

3–10 cm
1¼–4 in

CINNABAR BRACKET
Pycnoporus cinnabarinus
F: Polyporaceae

Growing on dead deciduous timber in Eurasia and N. America, this rare species has a bright reddish orange, leathery, annual bracket.

2–4 cm
¾–1½ in

PURPLEPORE BRACKET
Trichaptum abietinum
F: Polyporaceae

Found on fallen conifers in Eurasia and N. America, this fan-shaped bracket has concentric zones of pale grey, often tinged green by algae, with a purple margin.

5–12 cm
2–4¾ in

HAIRY BRACKET
Trametes hirsuta
F: Polyporaceae

This semicircular bracket is covered in minute hairs. It grows on dead deciduous wood or sometimes on old gorse stems in Eurasia and N. America.

TURKEYTAIL
Trametes versicolor
F: Polyporaceae

2–7 cm
¾–2¾ in

Found in Eurasia and N. America in a variety of colours, this species has brackets with concentric zones of different colours and a white pore surface.

fleshy, bright yellow-orange bracket

10–30 cm
4–12 in

LUMPY BRACKET
Trametes gibbosa
F: Polyporaceae

This cream-coloured bracket is often stained green from algae. Its pores may be long and maze-like. It grows on fallen deciduous logs in Eurasia and N. America.

small-lobed bracket

2–6 cm
¾–2¼ in

10–40 cm
4–16 in

WOOD CAULIFLOWER
Sparassis crispa
F: Sparassidaceae

Growing at the base of conifers in Eurasia and N. America, this species has cream lobes that are flattened and fleshy like a cauliflower.

HEN OF THE WOODS
Grifola frondosa
F: Sparassidaceae

Found in Eurasia and N. America, this species grows at the base of oak, often where lightening has struck. It has a dense cluster of small brackets.

basal stem

RUSSULALES

The best-known genuses within this order are *Russula* and *Lactarius*, which, although resembling typical mushrooms, are not related at all to the true Agaricales. Apart from the cap-and-stem shapes, Russulales produce fruitbodies in a wide range of forms. Most Russulales have spores with warts that stain blue-black in iodine solutions. When cut, the *Lactarius* species produce a latex, which may be white to coloured.

OAKBUG MILKCAP
Lactarius quietus
F: Russulaceae
Common under oaks in Eurasia, its reddish brown cap has darker zones, and the flesh has a sweet, oily smell.

LIVER MILKCAP
Lactarius hepaticus
F: Russulaceae
Associated with pines in Eurasia, this mushroom has a smooth cap with a grooved margin. The gills when cut bleed a white latex that stains yellow.

BEECH MILKCAP
Lactarius blennius
F: Russulaceae
This is a common species growing with beech in Eurasia. Slimy when wet, the grey-green cap has spots around the margin.

UGLY MILKCAP
Lactarius turpis
F: Russulaceae
A common species of birch woods in Eurasia and N. America, it is olive-green to almost black in colour and has a slimy cap.

SAFFRON MILKCAP
Lactarius deliciosus
F: Russulaceae
Found with pines in Eurasia and N. America, this fungus has an orange-zoned and spotted cap that stains green with age. The flesh bleeds orange-red latex.

WOOLLY MILKCAP
Lactarius torminosus
F: Russulaceae
Common under birches in Eurasia and N. America, this mushroom has a dark pink, hairy cap that is strikingly zoned.

CURRY MILKCAP
Lactarius camphoratus
F: Russulaceae
As the fruitbody of this fungus dries, it gives off a smell of curry, which persists for many weeks. It is found in Eurasia and N. America.

SOOTY MILKCAP
Lactarius fuliginosus
F: Russulaceae
Found in deciduous woods in Eurasia, this uncommon species has a dark brown cap and stem that bleed a white latex that rapidly turns pink.

PEPPERY MILKCAP
Lactifluus piperatus
F: Russulaceae
This uncommon species from mixed woods in Eurasia and N. America has a funnel-shaped cap with extraordinarily crowded, narrow gills. It exudes white latex when cut.

CHARCOAL BURNER
Russula cyanoxantha
F: Russulaceae

Growing in mixed woods in Eurasia and N. America, this mushroom's cap varies from purple-lilac to uniformly green. The gills are forked, flexible, and greasy.

BLOODY BRITTLEGILL
Russula sanguinaria
F: Russulaceae

Associated with pines in Eurasia and N. America, this species has a scarlet cap and red-streaked stem. Its spores are pale ochre.

GREEN BRITTLEGILL
Russula aeruginea
F: Russulaceae

Common under birches in Eurasia and N. America, this mushroom's pale olive to grass-green cap has tiny rust-coloured spots. Its spores are pale cream.

BEECHWOOD SICKENER
Russula mairei
F: Russulaceae

Exclusively found with beech in Eurasia, this species has a scarlet cap and bluish white gills.

YELLOW SWAMP BRITTLEGILL
Russula claroflava
F: Russulaceae

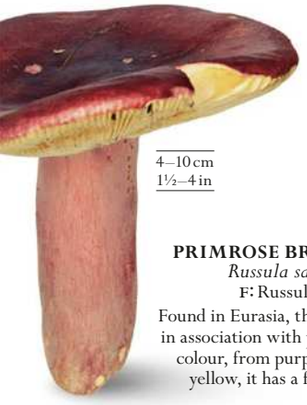
A common species on moss in boggy birch woods in Eurasia and N. America, its cap, yellowish cream gills, and white stem all bruise grey-black.

OCHRE BRITTLEGILL
Russula ochroleuca
F: Russulaceae

One of the commonest species found in Eurasia, it is identifiable by its matt yellow-ochre or greenish yellow cap and white gills.

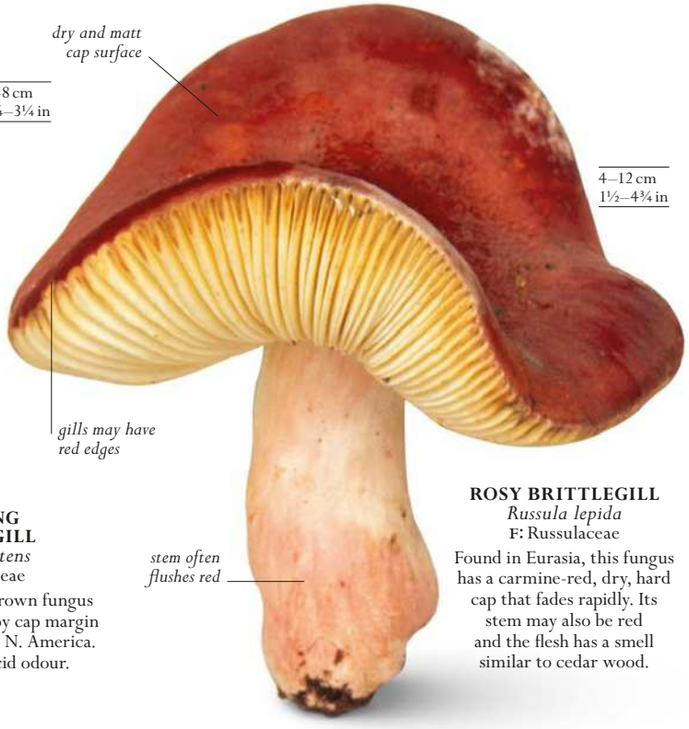
SICKENER
Russula emetica
F: Russulaceae

Growing in wet pine woods in Eurasia and N. America, the sickener has a bright scarlet cap that contrasts with its pure white gills and stem.



PRIMROSE BRITTLEGILL
Russula sardonia
F: Russulaceae

Found in Eurasia, this species grows in association with pine. Variable in colour, from purple to green or yellow, it has a fruity odour.



ROSY BRITTLEGILL
Russula lepida
F: Russulaceae

Found in Eurasia, this fungus has a carmine-red, dry, hard cap that fades rapidly. Its stem may also be red and the flesh has a smell similar to cedar wood.

STINKING BRITTLEGILL
Russula foetens
F: Russulaceae

This large, orange-brown fungus with a grooved, lumpy cap margin grows in Eurasia and N. America. It has a sour, rancid odour.

CRAB BRITTLEGILL
Russula xerampelina
F: Russulaceae

Found in Eurasia and N. America, this fungus is one of many related species that can only be identified under a microscope or by habitat.

EARPICK FUNGUS
Auriscalpium vulgare
F: Auriscalpiaceae

Growing on pine cones in Eurasia and N. America, this unique mushroom looks like a bent-over spoon with minute spines hanging down from the small, furry cap.

HAIRY CURTAIN CRUST
Stereum hirsutum
F: Stereaceae

Found in Eurasia and N. America, this mushroom varies in shape from fully crust-like to small overlapping brackets. It is hairy above and smooth below.

BLEEDING BROADLEAF CRUST
Stereum rugosum
F: Stereaceae

Growing in Eurasia and N. America, this species forms small crusts, and occasionally small brackets on wood. Its upper surface bleeds red where cut.

ROOT ROT
Heterobasidion annosum
F: Bondarzewiaceae

Usually parasitic on conifers in Eurasia and N. America, this species has a pale brown crust that darkens with age.

CORAL TOOTH
Hericium coralloides
F: Hericiaceae

Usually found on beech trees in Eurasia and N. America, this endangered species has white fruitbody branches with pendent spines on the lower surfaces.

AURICULARIALES

Although often grouped with other jelly fungi, the Auriculariales are separated by their unusual basidia (spore-producing cells). These vary in shape but all are partitioned by dividing membranes into four divisions, with each division producing a spore.

2–10 cm
¾–4 in

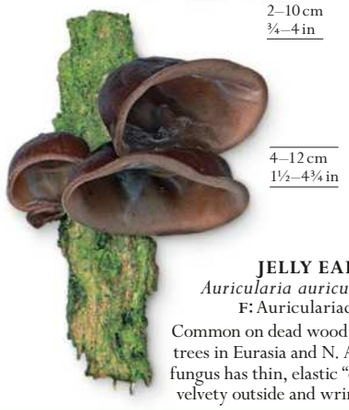
WITCHES' BUTTER
Exidia nigricans
F: Auriculariaceae

Found in temperate Eurasia and N. America, frequently on hardwood trees, it resembles a wrinkled mass of gelatinous tar. It shrivels when dry to a hard, black mass.

4–15 cm
1½–6 in

TRIPE FUNGUS
Auricularia mesenterica
F: Auriculariaceae

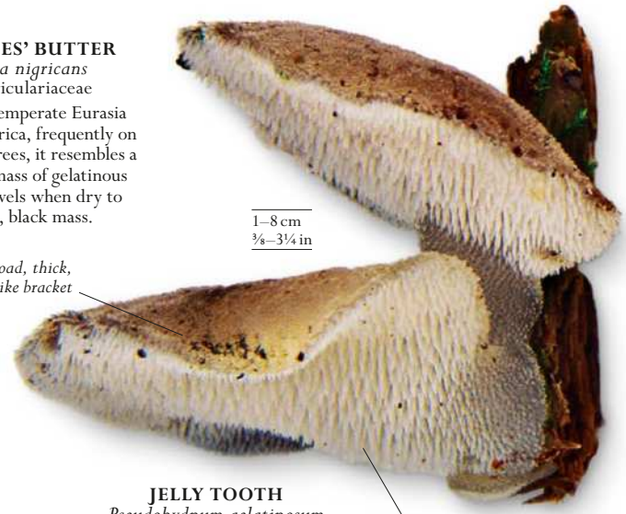
Found in Eurasia, this species is common on dead wood, especially elm. It resembles a small bracket fungus from the top, and has a wrinkled, rubbery, greyish purple underside.



4–12 cm
1½–4¾ in

JELLY EAR
Auricularia auricula-judae
F: Auriculariaceae

Common on dead wood of deciduous trees in Eurasia and N. America, this fungus has thin, elastic "ears" that are velvety outside and wrinkled inside.



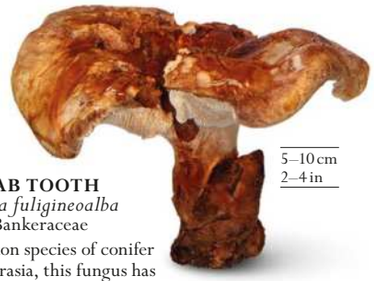
1–8 cm
⅜–3¼ in

JELLY TOOTH
Pseudohydnum gelatinosum
F: Incertae sedis

This species from Eurasia and N. America has a pale translucent grey to pale brown coloration. It is occasionally found on conifer stumps.

THELEPHORALES

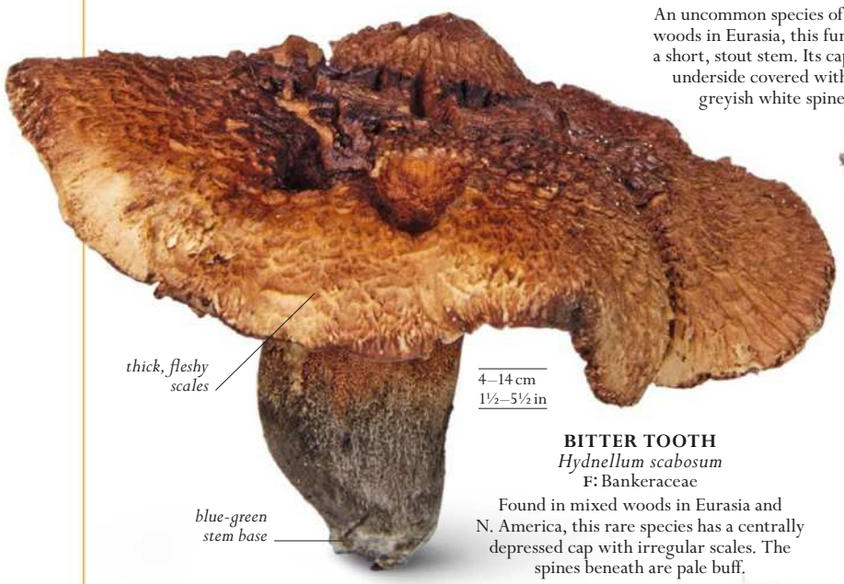
This diverse group includes bracket fungi, crust fungi, earthfans, and toothed fungi. Many of these have tough, leathery flesh, and commonly feature knobbed or spiny spores. The group was only identified as a result of molecular studies as the Thelephorales have few physical features in common.



5–10 cm
2–4 in

DRAB TOOTH
Bankera fuligineoalba
F: Bankeraceae

An uncommon species of conifer woods in Eurasia, this fungus has a short, stout stem. Its cap has an underside covered with tiny greyish white spines.



4–14 cm
1½–5½ in

BITTER TOOTH
Hydnellum scabosum
F: Bankeraceae

Found in mixed woods in Eurasia and N. America, this rare species has a centrally depressed cap with irregular scales. The spines beneath are pale buff.

3–10 cm
1¼–4 in

BLACK TOOTH
Phellodon niger
F: Bankeraceae

Growing in mixed woods in Eurasia and N. America, this uncommon species smells of fenugreek when dry. The irregularly shaped cap is grey to purplish black with grey spines underneath.

3–15 cm
1¼–6 in

DEVIL'S TOOTH
Hydnellum peckii
F: Bankeraceae

This locally common species from conifer woods in Eurasia and N. America has a flattened, knobbly, woolly cap that often exudes blood-red droplets. The underside has pale brown spines.

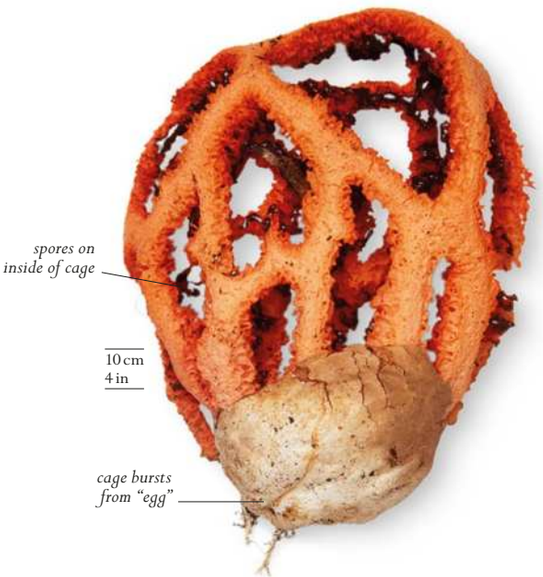
4–10 cm
1½–4 in

EARTHFAN
Thelephora terrestris
F: Thelephoraceae

Quite common in woods or on heaths in Eurasia and N. America, this fungus grows on soil or woody debris. Its fan-shaped fruitbodies overlap, forming clumps with paler, fringed margins.

PHALLALES

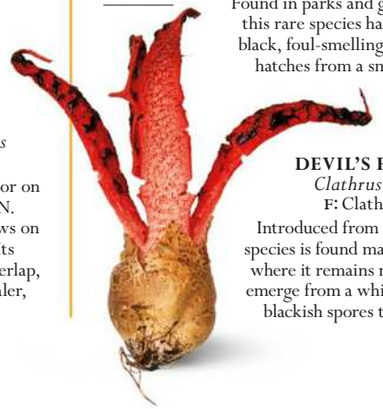
Named for the phallic shape of many of the species in this group, such as the stinkhorns, this order also contains some false truffles. The stinkhorns "hatch" from an egg-like structure, often in just a few hours.



10 cm
4 in

RED CAGE FUNGUS
Clathrus ruber
F: Clathraceae

Found in parks and gardens in Eurasia, this rare species has a red cage with black, foul-smelling spores. The cage hatches from a small, pale "egg".



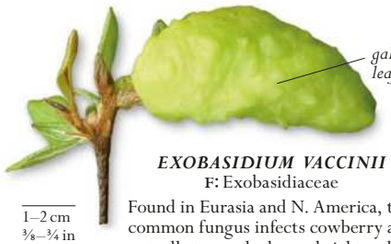
2.5–14 cm
1–5½ in

DEVIL'S FINGERS
Clathrus archeri
F: Clathraceae

Introduced from Australasia, this species is found mainly in S. Eurasia, where it remains rare. Its red arms emerge from a white "egg" and have blackish spores that smell fetid.

EXOBASIDIALES

This small group consists mainly of gall-forming plant parasites whose spore-producing cells form a layer on the leaf surface. Some cause disease in cultivated plants of the *Vaccinium* genus, which includes the common blueberry.



1–2 cm
⅜–¾ in

EXOBASIDIUM VACCINII
F: Exobasidiaceae

Found in Eurasia and N. America, this common fungus infects cowberry and eventually turns the leaves bright red. The leaves may become distorted and gall-like.

UROCYSTIDIALES

This order contains some well-known smut fungi, in particular species of the genus *Urocystis*. These are parasites of flowering plants such as anemone, onions, wheat, and rye, and often cause serious injury to the host plant.

2–4 mm
1/16–5/32 in

ANEMONE SMUT
Urocystis anemones
F: Urocystidaceae

This smut fungus from Eurasia and N. America forms dark brown, powdery, raised pustules on the leaves of anemones and some other plants.

DOG STINKHORN
Mutinus caninus
F: Phallaceae

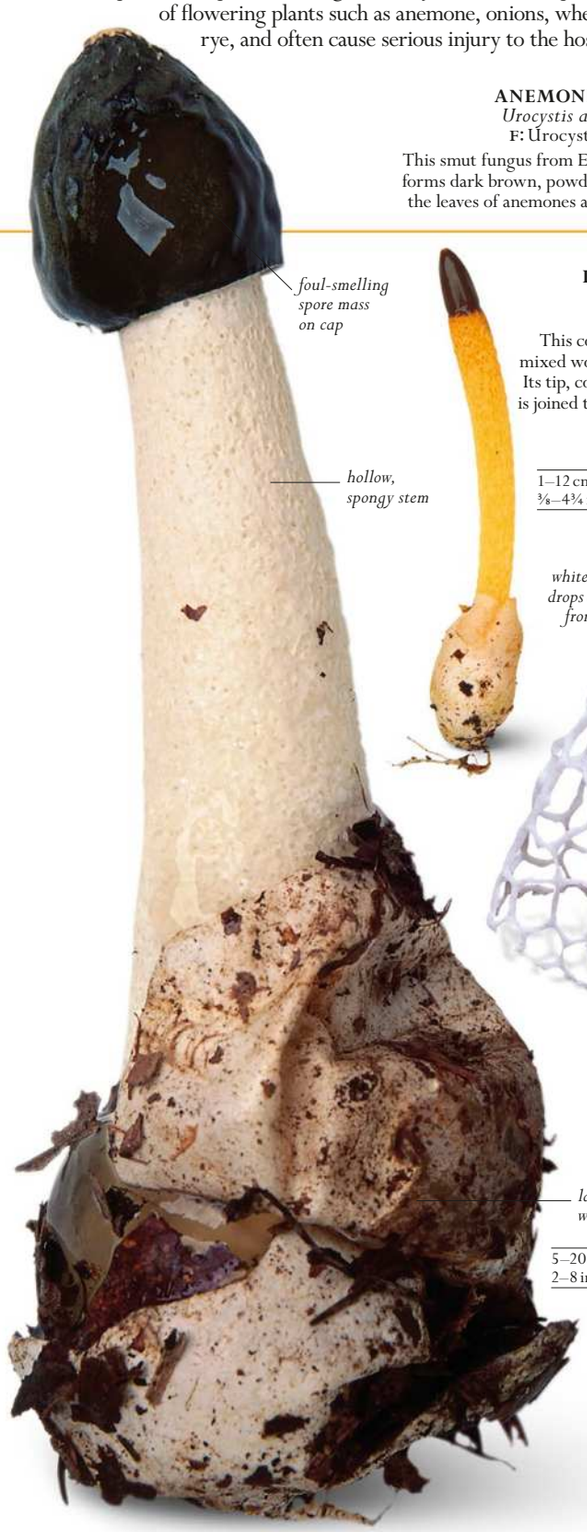
This common stinkhorn is found in mixed woods in Eurasia and N. America. Its tip, covered in greenish black spores, is joined to the spongy stem that emerges from a white "egg".

1–12 cm
⅜–4¾ in

5–20 cm
2–8 in

PHALLUS MERULINUS
F: Phallaceae

This tropical species is mainly found in Australasia. It hatches from a white "egg". There are many similar species, some with brightly coloured "skirts".



5–20 cm
2–8 in

STINKHORN
Phallus impudicus
F: Phallaceae

Common in mixed woods, this fungus is found in Eurasia. Its spore-covered, honeycomb-like cap hatches in a few hours from an "egg". Its foul odour is often evident many metres away.

PUCCINIALES

One of the largest orders of fungi with over 7,000 species, the rust fungi include numerous serious parasites of crop plants. They can have very complex life cycles with multiple hosts and produce different types of spores at different stages in their life.

RASPBERRY YELLOW RUST
Phragmidium rubi-idaei
F: Phragmidiaceae

This rust from Eurasia and N. America causes pustules to form on the upper surface of leaves. It survives winter with the help of black spores on the underside of leaves.

ROSE RUST
Phragmidium tuberculatum
F: Phragmidiaceae

This common rust is found in N. America and Eurasia. It causes orange pustules on the undersides of leaves and on distorted stems. The pustules turn black in late summer.

ALEXANDERS RUST
Puccinia smyrnii
F: Pucciniaceae

Found across Eurasia, this common rust fungus forms raised plaques or warts on the leaves of Alexanders (*Smyrnium olusatrum*).

HOLLYHOCK RUST
Puccinia malvacearum
F: Pucciniaceae

This serious pest of hollyhocks is found in Eurasia and N. America. It covers the leaves with small pustules. Older leaves die and fall off.

PUCCINIA ALLII
F: Pucciniaceae

Common on onions, garlic, and leeks in Eurasia and N. America, this species forms pustules on infected leaves. These break open to release dust-like airborne spores.

HYPERICUM RUST
Melampsora hypericorum
F: Melampsoraceae

This common species from Eurasia is visible as scattered, raised pustules on the undersides of *Hypericum* leaves.

FUCHSIA RUST
Pucciniastrum epilobii
F: Pucciniastraceae

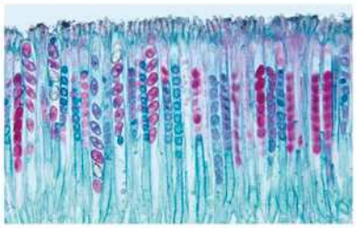
A parasite of fuchsias and fireweed in Eurasia, this species infects the leaves and forms pustules on the undersides of the leaves.

SAC FUNGI

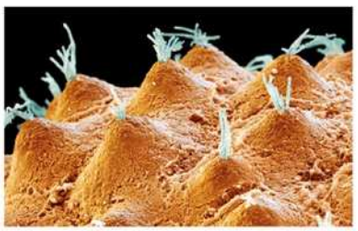
The Ascomycota, or sac fungi, are fungi that produce their spores in rounded to elongate sacs called asci located on the fertile surface of the fruitbody. They are the largest group of fungi, and include many cup- or saucer-shaped species.

PHYLUM	ASCOMYCOTA
CLASSES	7
ORDERS	56
FAMILIES	226
SPECIES	About 33,000

Many sac fungi display vivid colours, although it is uncertain what biological function such bright colours may have.



Spore-producing asci are shown here under a microscope. Arranged in dense layers, the asci contain eight spores each.



Many species form their asci in special protective chambers called perithecia; from here they discharge their spores.

DEBATE

HEROES OR VILLAINS?

Sac fungi form beneficial associations with plants, algae, and even arthropods such as beetles. But equally they include some of the world's most damaging pathogens: *Cryphonectria*, for example, is responsible for the recent death of millions of chestnut trees. Perhaps no other group of fungus has such contrasting effects on our world.

Ranging in size from the microscopic to around 20 cm (8 in) in height, the sac fungi occupy a wide variety of habitats, growing on dead, dying, and living tissue, and floating in fresh and saltwater environments. Many species are parasitic, and include some of the most serious crop pests. Others form mutually beneficial relationships, called mycorrhizae, with plants. Sac fungi include some of the most important fungi in the history of medicine, such as the source of penicillin, while others are serious pathogens – *Pneumocystis jirovecii*, for instance, can cause lung infections in people with a weak immune system. This phylum also contains the yeasts, which, being vital components in the production of alcohol and bread, have played a pivotal role in human history.

The Ascomycota display a wide range of fruitbody shapes, including cup-shaped, club-shaped, potato-like, simple crusts or sheets, pimple-like, coral-like, shield-shaped, or stalked with a sponge-like cap. Depending on the type of fruitbody, the spore-producing asci may grow externally on a special fertile layer or be contained internally. Not all species have a sexual stage; in fact, many use asexual methods of reproduction. Most yeasts grow and rapidly colonize new areas as a result of asexual division, or budding, where a small bud forms on the outside of a yeast cell, then separates, becoming a new cell.

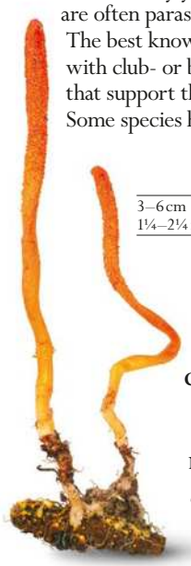
THE CUP FUNGUS

The common name of cup fungus refers to one of the most conspicuous shapes of fruitbody associated with the Ascomycota. Its open top (which is sometimes disc- or saucer-shaped) allows wind and rain to scatter the spores that line its inner surface. In some varieties, water is absorbed by the asci, which contain the spores, so that pressure builds up and forcibly ejects the spores up to 30 cm (12 in) from the fruitbody. Close examination of surfaces such as rotting logs, fallen branches, or leaves may reveal a fascinating world of almost microscopic cups. In the larger cup species, disturbance of the cup can produce such a vigorous ejection of spores that their release is not only visible as a faint cloud of spores, but also audible.

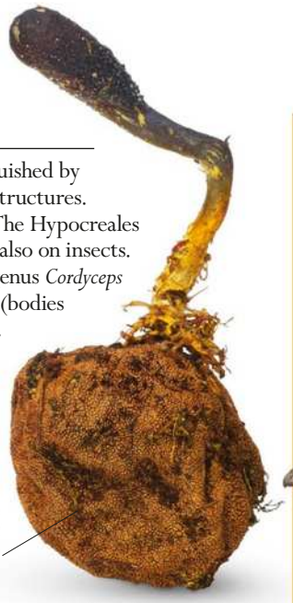
ORANGE PEEL CUP >
The orange peel fungus is a good example of the simple cup-shaped fruitbody adopted by many fungi species.

HYPOCREALES

The fungi in this order are usually distinguished by their brightly coloured, spore-producing structures. These are usually yellow, orange, or red. The Hypocreales are often parasitic on other fungi and also on insects. The best known among them is the genus *Cordyceps* with club- or branch-like fruitbodies (bodies that support the spore-forming cells). Some species have medicinal uses.



SCARLET CATERPILLAR CLUB
Cordyceps militaris
F: Cordycipitaceae
Found in Eurasia and N. America, this fungus is parasitic on moth pupae. The head of its club bears tiny spore-producing structures.



SNAKETONGUE TRUFFLECLUB
Tolypocladium ophioglossoides
F: Ophiocordycipitaceae
Parasitic on buried false truffles, this species is found in Eurasia and N. America. It forms yellow clubs with an elongated, greenish black head.

CORAL SPOT
Nectria cinnabarina
F: Nectriaceae
Abundant on damp wood in Eurasia and N. America, this fungus forms pink "pimples" when sexually immature and red-brown clusters when mature.

ERGOT
Claviceps purpurea
F: Clavicipitaceae
This species has caused outbreaks of mass poisoning. Found in Eurasia and N. America, it is parasitic on grass and cereal crops.

BOLETE EATER
Hypomyces chrysospermus
F: Hypocreaceae
This common mould, found in N. America and Eurasia on bolete, turns bright golden yellow, with a fluffy texture.

XYLARIALES

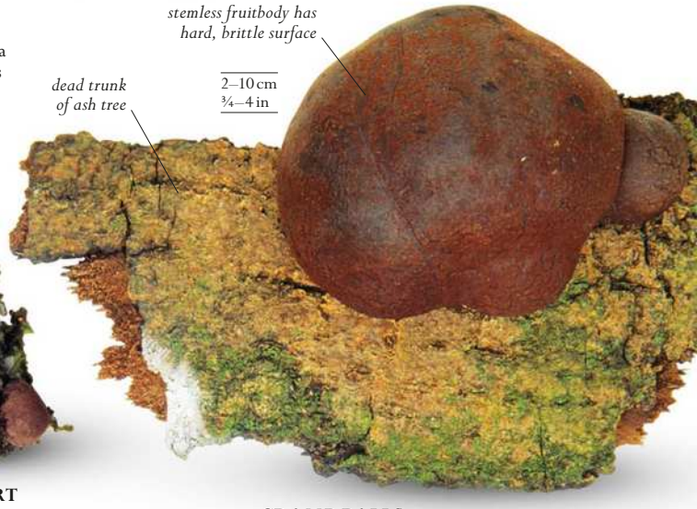
Members of this order often have their spore-producing cells in chambers, which are embedded in a woody growth called stroma. Although many species live on wood, some also occur on animal dung, fruit, leaves, and soil, or are associated with insects. The order includes many economically important plant parasites.

NAIL FUNGUS
Poronia punctata
F: Xylariaceae
Found on horse dung in Eurasia and N. America, this species is in decline. Its flattened disc has numerous tiny holes from which spores are released.

CANDLESNUFF FUNGUS
Xylaria hypoxylon
F: Xylariaceae
Common on dead wood in Eurasia and N. America, this species resembles a snuffed-out candle with a velvety black stem.

DEAD MAN'S FINGERS
Xylaria polymorpha
F: Xylariaceae
Growing on dead wood in Eurasia and N. America, this fungus forms brittle black clubs with a rough surface, tiny pores, and thick, white flesh.

BEECH WOODWART
Hypoxylon fragiforme
F: Xylariaceae
Occurring in clusters on beech logs, this European and N. American species forms hard, rounded fruitbodies with tiny spore-releasing chambers.



CRAMP BALLS
Daldinia concentrica
F: Xylariaceae
Found in Eurasia and N. America, this fungus has rounded fruitbodies that reveal concentric whitish zones when cut in half. They eject black spores from their outer layer.

ERYSIPHALES

Parasitic on leaves and fruit of flowering plants, the Erysiphales are powdery mildews. The hyphae (filaments) of their mycelium (vegetative part of the fungus) penetrate the cells of the host plant and take up nutrients.

OAK POWDERY MILDEW
Erysiphe alphitoides
F: Erysiphaceae
Growing on oaks in Eurasia and N. America, this fungus covers young leaves, causing them to shrivel and blacken.

APPLE POWDERY MILDEW
Podosphaera leucotricha
F: Erysiphaceae
Common on apple leaves in Eurasia and N. America, this mildew appears first on the underside of leaves as whitish patches, before spreading rapidly.

POWDERY MILDEW
Golovinomyces cichoracearum
F: Erysiphaceae
Found in Eurasia and N. America, this species appears on members of Asteraceae (the sunflower family), causing patches on leaves, which eventually die.

CAPNODIALES

Commonly called sooty moulds, these sac fungi are frequently found on leaves. They feed on the honeydew excreted by insects or on liquid exuded from the leaves. Some cause skin problems in humans.

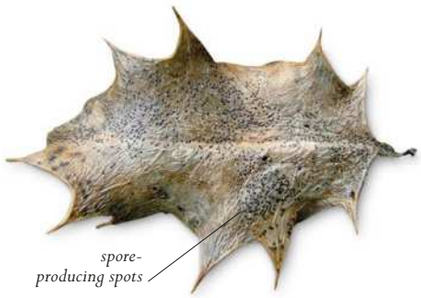
CLADOSPORIUM CLADOSPORIOIDES
F: Davidiellaceae
This mould, common in Eurasia and N. America, grows on damp bathroom walls. It may cause an allergic reaction in some people.

HELOTIALES

The fungi of this order are distinguished by their disc- or cup-shaped fruitbodies, unlike some similar cup fungi. Their sac-like spore-producing cells, or asci, do not have an apical lid (a flap through which they open). Most members live on humus-rich soil, dead logs, and other organic matter. This order also includes some of the most damaging plant parasites.

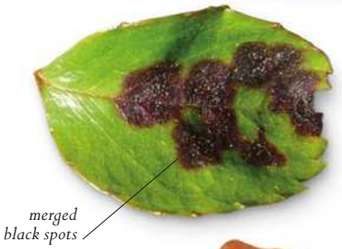
BROWN CUP
Rutstroemia firma
F: Rutstroemiaceae

Consisting of a light brown cup and a narrow stem, this fungus grows on fallen branches, especially of oaks, in Europe. It turns the host wood black.



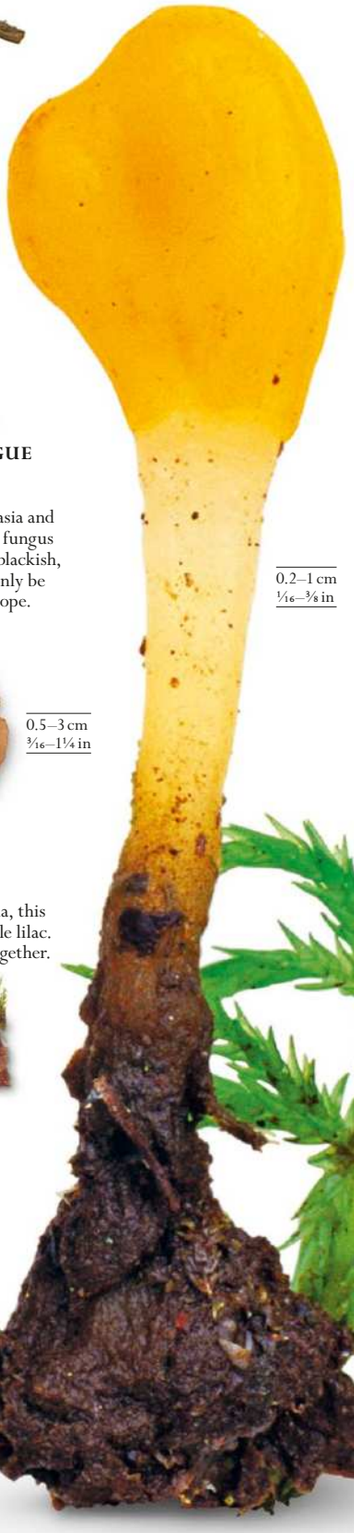
TROCHILA ILICINA
F: Dermateaceae

Abundant on fallen holly leaves, this fungus is found in Eurasia and N. America. It forms spore-producing spots on the leaf surface.



ROSE BLACK SPOT
Diplocarpon rosae
F: Dermateaceae

Commonly found on rose leaves in Eurasia and N. America, this fungus causes black spots, which merge together to cause large black patches.



SCALY EARTHTONGUE
Geoglossum fallax
F: Geoglossaceae

Growing in meadows in Eurasia and N. America, this uncommon fungus is one of several species with blackish, flattened clubs, which can only be separated using a microscope.

BLACK BULGAR
Bulgaria inquinans
F: Bulgariaceae

Found in Eurasia and N. America, this species has a brown outer surface. Its spore-producing inner surface is smooth, black, and rubbery.

ANEMONE CUP
Dumontinia tuberosa
F: Sclerotiniaceae

Parasitic on the tubers of anemones, this common Eurasian species has a long, black stem and a simple brown cup.

BEECH JELLYDISC
Neobulgaria pura
F: Helotiaceae

Frequently found on fallen beech logs in Eurasia, this translucent jellydisc varies from pale pink to pale lilac. The discs are often distorted from crowding together.

APPLE BROWN ROT
Monilia fructigena
F: Sclerotiniaceae

Very common in Eurasia, this fungus occurs primarily on apples and pears, although it is also found on *Prunus* sp., causing brown fruit rot.

LEMON DISCO
Bisporella citrina
F: Helotiaceae

Very common on dead hardwood in Eurasia, this species occurs in clusters. Its golden-yellow discs sometimes cover entire branches.

JELLY BABIES
Leotia lubrica
F: Leotiaceae

Frequently found in mixed woodland in Eurasia and N. America, this species has a lobed head with a margin that rolls back on itself.

GREEN ELFCUP
Chlorociboria aeruginascens
F: Helotiaceae

Found in Eurasia and N. America, the blue-green mature cups are rather uncommon, but the green stains they cause on fallen oak logs are easily visible.

LARGE PURPLE DROP
Ascocoryne cylichnium
F: Helotiaceae

Quite common on fallen beech logs in Eurasia, this species attaches itself centrally to the wood and forms gelatinous, irregular discs when sexually mature.

BOG BEACON
Mitrula paludosa
F: Helotiaceae

This species, found in Eurasia and N. America, grows on plant remains in shallow water in spring and early summer. It has a rounded to tongue-shaped head.

PEZIZALES

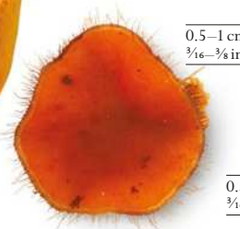
Members of this order produce spores inside sac-like structures, or asci, which typically open by rupturing to form an operculum (terminal lid) and eject the spores. The order includes a number of species of economic importance, such as morels, truffles, and desert truffles.

COMMON EARTHCUP
Geopora arenicola
F: Pyronemataceae

Common in Eurasia, this fungus is difficult to spot as it lies buried in sandy soils. It has a smooth, spore-producing inner surface.

HARE'S EAR
Otidea onotica
F: Pyronemataceae

This common species is often found in clusters in broadleaf forests in Eurasia and N. America. Its tall cups are split down on one side.



COMMON EYELASH
Scutellinia scutellata
F: Pyronemataceae

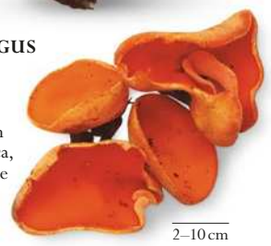
This is one of many similar species; its fruitbody is a scarlet cup with a fringe of black hairs. This fungus is common on wet, rotten wood in Eurasia and N. America.

TOOTHED CUP
Tarzetta cupularis
F: Pyronemataceae

A common species in alkaline soils in woods of Eurasia and N. America, its goblet-like cup has a short stem.

FALSE MOREL
Gyromitra esculenta
F: Discinaceae

This poisonous species is found throughout N. America and Eurasia, and usually grows under conifers in spring. The shiny brown cap looks like a wrinkled brain.

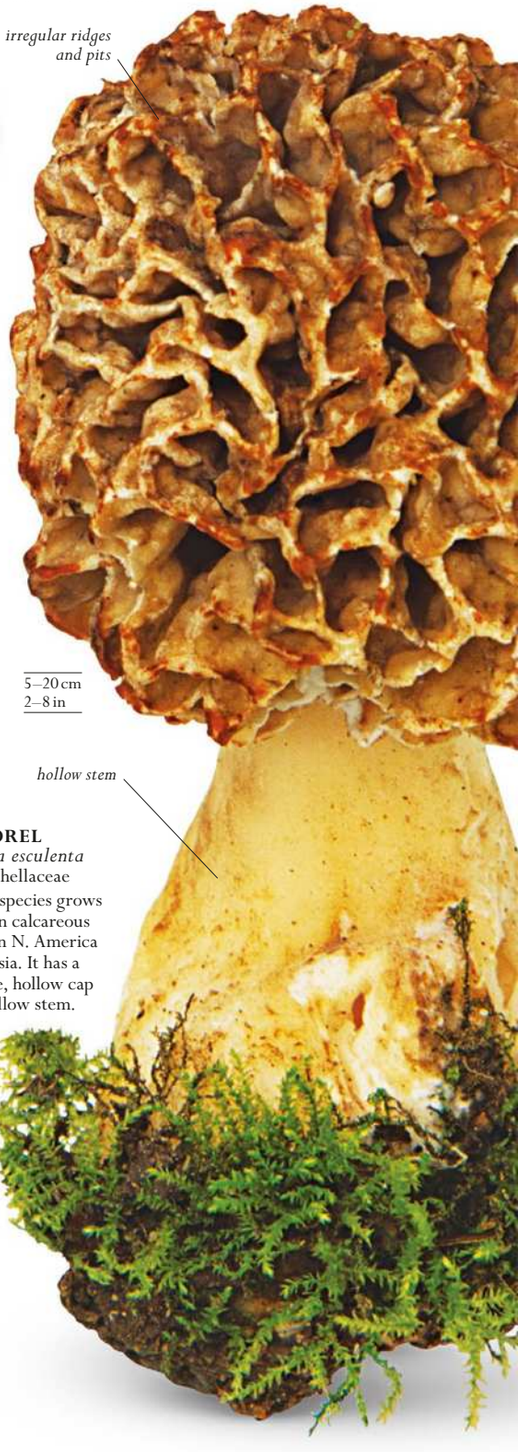


ORANGE PEEL FUNGUS
Aleuria aurantia
F: Pyronemataceae

Often found along gravelly dirt tracks in Eurasia and N. America, this is an unmistakable species, with thin, orange caps.

BLEACH CUP
Disciotis venosa
F: Morchellaceae

Growing in spring in damp woodland in Eurasia and N. America, this short-stemmed species has a chlorine-like smell. Its inner surface is brown and wrinkled and the outer surface is pale.



HALF-FREE MOREL
Morchella semilibera
F: Morchellaceae

This hollow morel looks like a dark, ridged thimble on a scurfy, pale stem. It is common in spring in mixed woods in Eurasia and N. America.

THIMBLE MOREL
Verpa conica
F: Morchellaceae

An uncommon species, this fungus grows in woods and hedges on chalky soils in Eurasia and N. America. Its smooth, thimble-like cap sits on a hollow stem.

BLACK MOREL
Morchella elata
F: Morchellaceae

Common in woods during spring in Eurasia and N. America, this species has a pinkish buff to black cap, with cross-connected black ridges, and a hollow stem.

MOREL
Morchella esculenta
F: Morchellaceae

This prized species grows in spring in calcareous woodland in N. America and Eurasia. It has a sponge-like, hollow cap and a hollow stem.

BLISTERED CUP
Peziza vesiculosa
F: Pezizaceae

Common in Eurasia and N. America, this fungus typically occurs in clusters on compost, straw, or manure. Its brittle cups can have ragged edges.

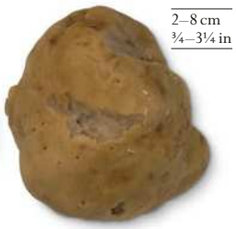
CELLAR CUP
Peziza cerea
F: Pezizaceae

Found across Eurasia and N. America, this fungus often occurs on damp brickwork. It is dark ochre on the inside and pale outside.

BAY CUP
Peziza badia
F: Pezizaceae

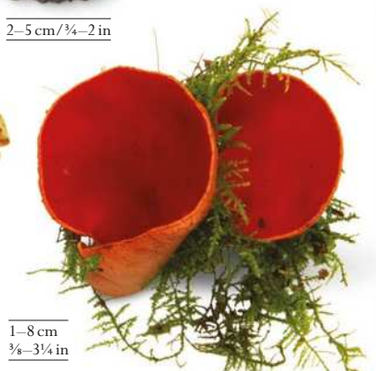
One of many similar species, this common fungus of Eurasian and N. American woods has a spore-producing inner surface. Its brown cup develops an olive tint with age.

PERIGORD TRUFFLE
Tuber melanosporum
F: Tuberaceae
This highly prized truffle grows underground around oaks in the Mediterranean region. The truffles are found using dogs or pigs.



WHITE TRUFFLE
Tuber magnatum
F: Tuberaceae
Prized in Italy and France, this expensive truffle of alkaline soils in S. Europe can be cultivated on suitable host trees such as oak and poplar, by inoculation.

SUMMER TRUFFLE
Tuber aestivum
F: Tuberaceae
Found across S. and C. Europe, this highly valued truffle grows underground, near a variety of broadleaf trees.



SCARLET ELFCUP
Sarcoscypha austriaca
F: Sarcoscyphaceae
Found from winter to early spring on fallen branches in Eurasia and N. America, this species has a scarlet cup contrasting with its pale outer surface.

WHITE SADDLE
Helvella crispa
F: Helvellaceae
Possibly poisonous, this species is common in mixed woods in Eurasia and N. America. Its thin, saddle-like cap sits on a fragile, ribbed stem.

ELFIN SADDLE
Helvella lacunosa
F: Helvellaceae
Found in mixed woods in Eurasia and N. America, this common species has a lobed, dark cap on a grey, fluted, and columned stem.

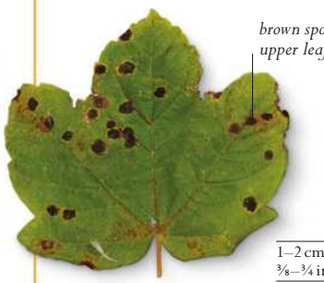
EUROTIALES

Better known for the blue and green moulds, this order includes the fungi *Penicillium* (famous for producing penicillin, the first discovered antibiotic) and *Aspergillus* (a significant cause of disease in humans).

FALSE TRUFFLE
Elaphomyces granulatus
F: Elaphomycetaceae
Common in sandy soils below conifers in Eurasia and N. America, this reddish brown truffle has a roughened surface and purple-black inner spore-mass.

RHYTISMATALES

Commonly called tar spot fungi, the species in this order infect plant matter, such as leaves, twigs, bark, female conifer cones, and occasionally berries. Many species attack the needles of conifers, causing needle drop. The tar spot of maple leaves is perhaps the most frequently seen.



TAR SPOT
Rhytisma acerinum
F: Rhytismataceae
Abundant on acer or maple trees in N. America and Eurasia, this fungus causes irregular spots, with paler yellow margins, which disfigure the leaves.

YELLOW FAN
Spathularia flavida
F: Cudoniaceae
This common species grows in wet, mossy conifer woods of Eurasia and N. America. It has flattened, pale to darker yellow, rubbery heads.

TAPHRINALES

This order contains many plant parasites, with most species in the genus *Taphrina*. All species have two growth states: in the saprophytic state, they are yeast-like and propagate by budding; but in the parasitic state, they emerge through plant tissues, causing distorted leaves and galls.

PEACH LEAF CURL
Taphrina deformans
F: Taphrinaceae
This fungus infects most varieties of peach and nectarine trees in Eurasia and N. America. The affected leaves curl and crinkle, and frequently turn reddish purple.

BIRCH BESOM
Taphrina betulina
F: Taphrinaceae
Found across Eurasia, this common species causes witches' broom, a disease of birch trees that causes clumps of narrow twigs to grow at branch ends.

PLEOSPORALES

Typical members of this order develop their asci within a flask-like fruiting body. The asci have two wall layers: at maturity, the inner wall protrudes beyond the outer wall, ejecting the spores. Many species grow on plants; some form lichens.

PEAR SCAB
Venturia pyrina
F: Venturiaceae
Found in pear orchards in Eurasia and N. America, this common parasite causes the fruit to distort, discolour, and even drop before it is ripe.

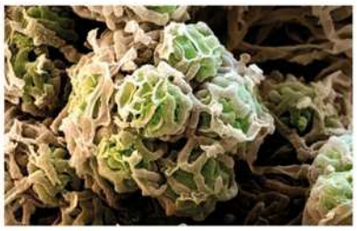
LEPTOSPHAERIA ACUTA
F: Leptosphaeriaceae
Found in Eurasia and N. America, this common species infects the dead stems of the stinging nettle, *Urtica dioica*. It forms tiny cones that push through the stem surface of the host in order to eject its spores.

BOEREMIA HEDERICOLA
F: Didymellaceae
Found in Eurasia and N. America, this species causes circular white lesions on the leaves of the ivy plant, which turn brown and die.

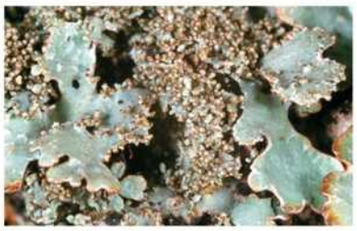
LICHENS

From outcrops of rock exposed to the sea to desert areas where the only place they can grow is inside the rock itself, lichens survive in the harshest parts of the world. They are some of nature's pioneers, creating foundations on which others can live.

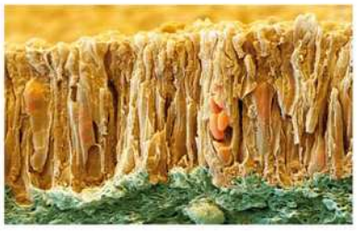
PHYLA	ASCOMYCOTA BASIDIOMYCOTA
CLASSES	10
ORDERS	15
FAMILIES	40
SPECIES	About 18,000



Asexual soredia are bundles of fungal hyphae (filaments) and algal cells. Here they are budding off and awaiting dispersal.



Asexual isidia are tiny peg-like cells on the edge of the lichen, which break off to form new colonies of lichen.



Lichen cells are shown here in microscopic cross-section. Spore-producing asci rise from algal cells.

DEBATE

UNLIKELY PARTNERS?

Lichen evolution remains a mystery. Scientists are still trying to understand how and why fungi and algae came to live together. It may have started as an attack on one by the other, which developed into a partnership. Not all lichen associations are necessarily mutually beneficial – some may be parasitic rather than a partnership.

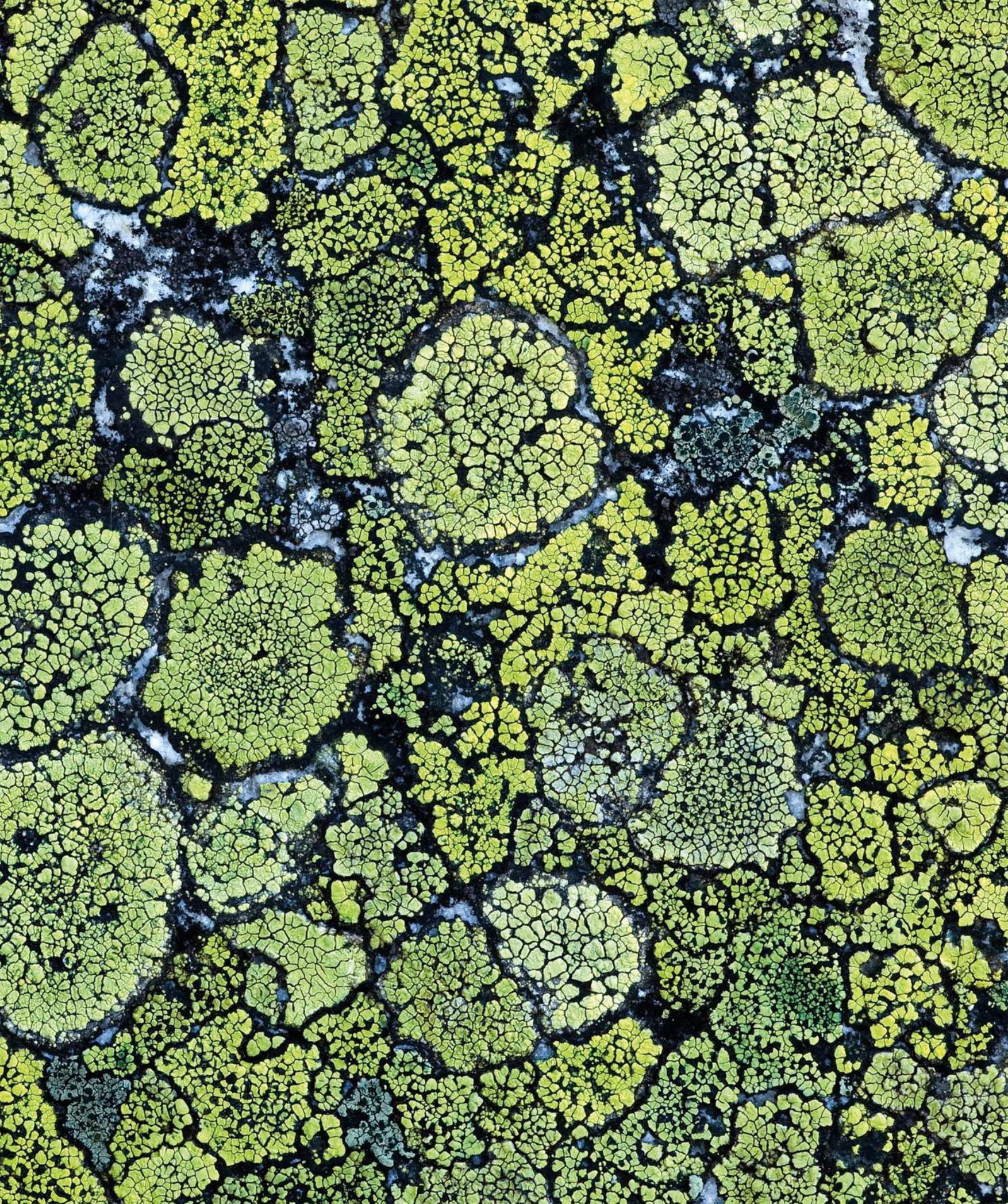
A lichen is not a single organism, but a composite consisting of a green alga or cyanobacterium and a fungus, living together in a mutually beneficial association. The algal partner provides nutrients through photosynthesis, while the fungal partner aids the alga by retaining water and capturing mineral nutrients. The fungus is normally a member of the Ascomycota (the sac fungi), or, more rarely, of the Basidiomycota (mushrooms) – lichen classification reflects the type of fungus involved. Typically, the fungus surrounds the photosynthetic cells of the alga, enclosing them within special fungus tissues unique to lichens. It appears that although neither partner is capable of surviving on its own, together they can endure the most extreme conditions. Lichens have even been found some 400 km (250 miles) from the South Pole, but they also grow in familiar places, such as dry-stone walls, rocks, and bark.

Lichens broadly fall into three types, based on shape: foliose lichens, which have leaves; crustose lichens, which form a crust; and fruticose lichens, which have branches. However, there are some that defy this categorization, such as filamentous (hair-like) and gelatinous (water-absorbent) lichens.

REPRODUCTION

Many lichens reproduce sexually by means of spores. These are produced by the fungal half of the partnership and are usually formed in special cup- or disc-like structures called apothecia. These spores, once ejected, must land next to a suitable algal partner if they are to form another lichen and survive. Other lichens produce spores inside special chambers called perithecia, which are like microscopic volcanoes, releasing their spores through a hole at the top. Alternatively, lichens may reproduce asexually by budding or breaking off specialized parts of their body. These soredia or isidia contain a mix of fungal and algal cells, which, if they land in a suitable habitat, will go on to form new lichen colonies. Rocky shorelines in North America are home to vast colonies of lichens several kilometres in length. These will have taken hundreds or even thousands of years to spread to such a huge size.

SPREADING MAP LICHEN >
Typical of lichens, *Rhizocarpon* is able to colonize harsh environments such as dry, exposed rock surfaces.



5–10 cm
2–4 in

ORANGE LICHEN
Caloplaca verruculifera
F: Teloschistaceae
This lichen has radiating lobes with apothecia (spore-producing discs) at the centre. It is found on rocks in coastal areas in Eurasia and N. America, often near bird perches.

2.5–7.5 cm
1–3 in

GOLDEN-EYE LICHEN
Teloschistes chrysophthalmus
F: Teloschistaceae
A critically endangered species in Eurasia, America, and the tropics, this lichen grows on shrubs and small trees in old orchards and hedgerows. Its branched lobes produce large, orange discs.

2.5–7.5 cm
1–3 in

rounded lobes that lift at edges

COMMON WALL LICHEN
Xanthoria parientina
F: Teloschistaceae
Growing on trees, walls, and roofs in N. America, Eurasia, Africa, and Australia, this lichen has rounded, yellow-orange lobes.

5–15 cm/2–6 in

BEARD LICHEN
Usnea filipendula
F: Parmeliaceae
Found mainly in northern regions, this species forms green-grey, pendent clumps on trees. Spiny apothecia form at the tips.

2.5–7.5 cm
1–3 in

REINDEER MOSS
Flavocetraria nivalis
F: Parmeliaceae
Found on mountain heaths and upland moors in N. America and Eurasia, this species has brownish, flattened leafy fronds with spiny margins.

2.5–7.5 cm
1–3 in

HAMMERED SHIELD LICHEN
Parmelia sulcata
F: Parmeliaceae
This lichen's flattened lobes are grey-green, with rounded tips and powdery, reproductive structures on the surface. It is commonly found on trees in N. America and Eurasia.

2.5–7.5 cm
1–3 in

HOARY ROSETTE LICHEN
Physcia aipolia
F: Physciaceae
Growing on tree bark in Eurasia and the Americas, this grey to brownish grey species forms rough patches with a lobed margin. It has black apothecia.

2.5–7.5 cm
1–3 in

POWDER-HEADED TUBE-LICHEN
Hypogymnia tubulosa
F: Parmeliaceae
Common on twigs and tree trunks, this lichen has lobes that are grey-green above and dark underneath. It is found in Eurasia and N. America.

2.5–7.5 cm
1–3 in

HOODED TUBE-LICHEN
Hypogymnia physodes
F: Parmeliaceae
Found worldwide on trees, rocks, and walls, this lichen has pale grey-green lobes with wavy margins. The rare apothecia are red-brown with grey margins.

1–5 cm
⅜–2 in

DEVIL'S MATCHSTICK
Cladonia floerkeana
F: Cladoniaceae
This species is common on peaty soil in Eurasia and N. America. It forms a crust of greenish grey scales from which stalks emerge, tipped with scarlet apothecia.

2.5–12.5 cm
1–5 in

CARTILAGE LICHEN
Ramalina fraxinea
F: Ramalinaceae
Growing on trees in Eurasia and N. America, this species forms flattened, grey-green branches dotted with apothecia.

2.5–10 cm
1–4 in

CORAL LICHEN
Sphaerophorus globosus
F: Sphaerophoraceae
Found on rocks in mountainous areas of N. Eurasia and N. America, this fungus forms dense cushions of pinkish brown branches with globular apothecia.

2.5–10 cm
1–4 in

BLACK SHIELDS
Tephromela atra
F: Mycoblastaceae
This lichen has pale grey crustose lobes that look like dried porridge. Its apothecia are black. The lichen is found on exposed rocks in N. America and Eurasia.

2.5–10 cm/1–4 in

STONEWALL RIM-LICHEN
Lecanora muralis
F: Lecanoraceae
This lichen often grows on concrete and on rocks. Its grey-green lobes radiate outwards. It is found in Eurasia and N. America.

2.5–10 cm
1–4 in

REINDEER LICHEN
Cladonia portentosa
F: Cladoniaceae
One of several reindeer lichens, this species is common on heath and moorland in N. America and Eurasia. Its thin, hollow branches repeatedly divide.

5–50 cm
2–20 in

BLACK TAR LICHEN
Verrucaria maura
F: Verrucariaceae

Occurring on rocks along seashores in Eurasia and N. America, this species has a dark grey, cracked crust that contains apothecia.

20–30 cm
8–12 in

DOG LICHEN
Peltigera praetextata
F: Peltigeraceae

Found on rocks in Eurasia and N. America, this lichen has large grey-black lobes, with paler margins and reddish brown apothecia.

2.5–5 cm
1–2 in

BLISTERED JELLY LICHEN
Collema furfuraceum
F: Collemataceae

This lichen has flat, gelatinous, wrinkled lobes. It is found on rocks and trees in areas with high rainfall in Eurasia and N. America.

green lobes spread out from centre

5–15 cm
2–6 in

TREE LUNGWORT
Lobaria pulmonaria
F: Lobariaceae

Mainly found on tree bark in coastal areas in Eurasia, N. America, and Africa, this species is declining due to habitat loss.The branching lobes are pale orange underneath.

5–20 cm
2–8 in

ROCK TRIPE
Lasallia pustulata
F: Umbilicariaceae

This Eurasian and N. American lichen forms colonies on nutrient-rich rocks in coastal or upland areas. It has a grey-brown upper surface with many oval pustules.

2.5–7.5 cm
1–3 in

PETALLED ROCK-TRIPE
Umbilicaria polyphylla
F: Umbilicariaceae

A common species on rocks in mountains in Eurasia and N. America, it has smooth, broad lobes that are dark brown above and black beneath.

5–10 cm
2–4 in

black, slit-like openings release spores

COMMON SCRIPT LICHEN
Graphis scripta
F: Graphidaceae

Often seen on tree bark in N. America and Eurasia, this lichen forms a thin, grey-green crust with slit-like openings.

2.5–7.5 cm
1–3 in

PERTUSARIA PERTUSA
F: Pertusariaceae

Common on tree bark in Eurasia and N. America, this lichen forms grey crusts with a pale margin. The crusts are covered with groups of warts with tiny openings.

2.5–10 cm
1–4 in

LECIDEA LICHEN
Lecidea fuscoatra
F: Lecideaceae

This species is common on siliceous rocks and old brick walls in N. America and Eurasia. It forms a grey, cracked crust, with sunken, black apothecia.

5–65 mm
¾6–2½ in

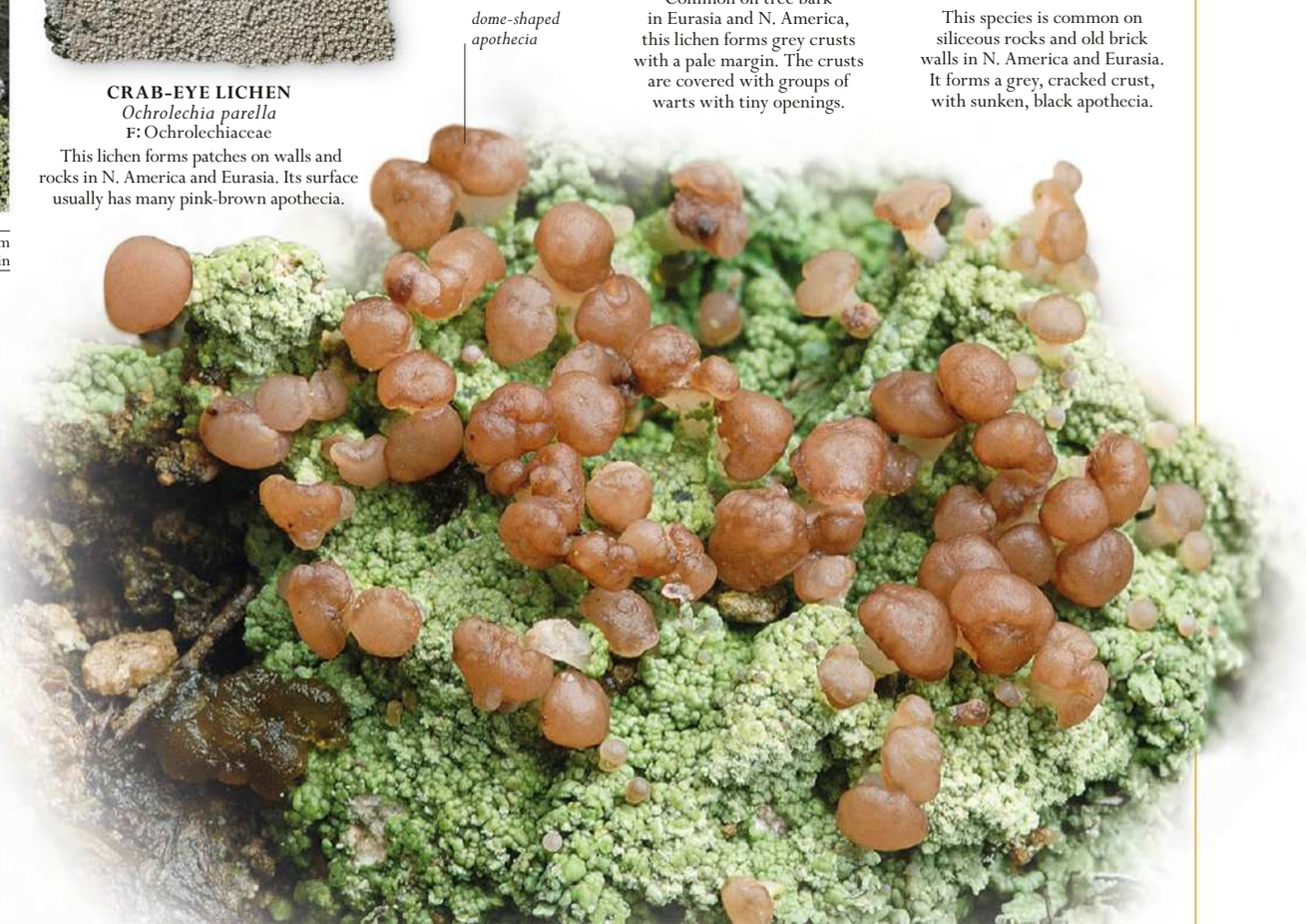
MAP LICHEN
Rhizocarpon geographicum
F: Rhizocarpaceae

Common on rocks in mountains in northern regions and Antarctica, this lichen forms a flat patch bordered by a black line of spores. Groups of these lichens have a patchwork appearance.

5–20 cm
2–8 in

CRAB-EYE LICHEN
Ochrolechia parella
F: Ochrolechiaceae

This lichen forms patches on walls and rocks in N. America and Eurasia. Its surface usually has many pink-brown apothecia.



dome-shaped apothecia

2.5–12.5 cm
1–5 in

BAEOMYCES RUFUS
F: Baeomycetaceae

Forming grey-green crusts on sandy soil and rocks, this lichen has brown ball-like apothecia on stalks a few millimetres high. It is found in Eurasia and N. America.

ANIMA

LS

Animals make up the largest kingdom of living things. Driven by the need to eat food, and to escape being eaten, they are uniquely responsive to the world around them. The vast majority are invertebrates, but mammals and other chordates often outclass them in size, strength, and speed.

» 250

INVERTEBRATES

Hugely varied in shape, invertebrates also have a wide range of lifestyles. Insects make up the largest group, but others include jellyfish, worms, and animals protected by a hard shell.

» 322

CHORDATES

Most of the world's large animals are chordates. Externally, they can be covered in fur, feathers, or overlapping scales, but internally nearly all have a backbone, which makes up part of a bony skeleton.

INVERTEBRATES

With about 1.4 million species identified, animals make up the largest kingdom of living things on Earth. The vast majority of them are invertebrates – animals without a backbone. Invertebrates are extraordinarily varied; many are microscopic, but the largest are over 10 m (33 ft) long.

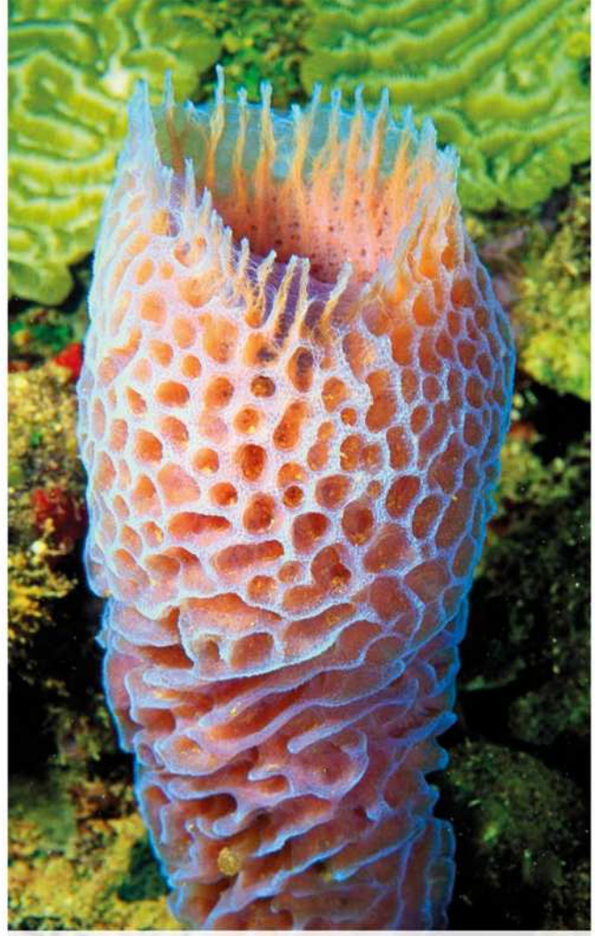
Invertebrates were the first animals to evolve. Initially, they were small, soft-bodied, and aquatic – features that many living invertebrates still share. During the Cambrian Period, which ended about 485 million years ago, invertebrates underwent a spectacular burst of evolution, developing a huge range of body forms and some very different ways of life. This evolutionary explosion produced almost all the major phyla, or groups, of invertebrates that exist today.

GREAT DIVERSITY

There is no such thing as a typical invertebrate, and many of the phyla have very little in common. The simplest kinds do not have a head or a brain, and usually rely on internal fluid pressure to keep their shape. At the other extreme, arthropods have a well-developed nervous system and elaborate sense organs, including complex eyes. Crucially, they also have an external body case, or exoskeleton, with legs that bend at flexible joints. This particular body plan has proved to be remarkably successful, allowing arthropods to invade every natural habitat in water, on land, and in the air. Invertebrates also include animals that have a shell, and ones that are reinforced by mineral crystals or hard plates. Only vertebrates, however, have an internal skeleton made of bone.

SPLIT LIVES

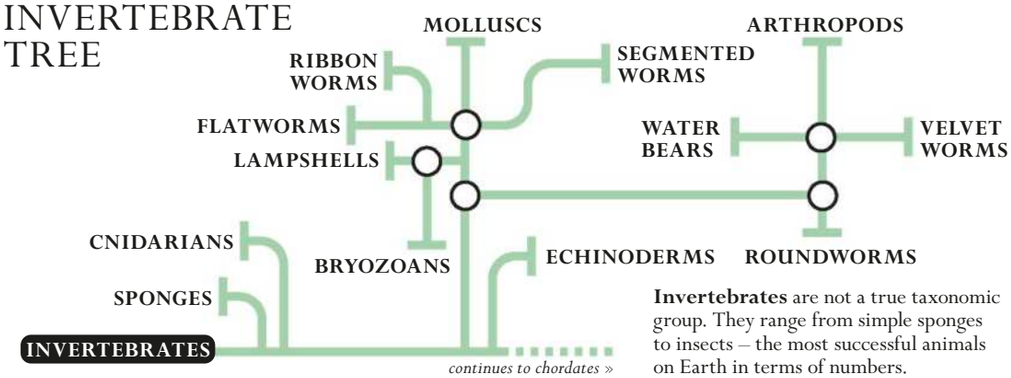
Most invertebrates begin life as an egg. Some look like miniature versions of their parents when they hatch, but many start life with a very different body form. These larvae change shape, food sources, and feeding methods as they grow up. For example, sea urchins have drifting larvae, which filter food from the sea, while the adults scrape algae from rocks. The change in shape – metamorphosis – can be gradual, or it can take place abruptly, with the young animal's body being broken down, and an adult body being assembled in its place. Metamorphosis enables invertebrates to exploit more than one food source, and it also helps them to spread, often over great distances.



SPONGES
Among the simplest animals, sponges have a sieve-like body, with an internal skeleton of mineral crystals. Classified as the phylum Porifera, there are more than 9,000 species.

ARTHROPODS
The phylum Arthropoda is the biggest in the animal kingdom, with over 1.2 million species identified. It includes insects, crustaceans, arachnids, centipedes, and millipedes.

INVERTEBRATE TREE



Invertebrates are not a true taxonomic group. They range from simple sponges to insects – the most successful animals on Earth in terms of numbers.

CNIDARIANS
Members of the phylum Cnidaria are soft-bodied invertebrates that kill their prey with stinging cells. Of the 11,947 known species, the vast majority are marine.

FLATWORMS
Numbering about 30,000 species, the phylum Platyhelminthes contains animals with a flat, thin body, and a distinguishable head and tail.

SEGMENTED WORMS
With about 18,000 species, the phylum Annelida contains worms that have a sinuous body, which is divided into ring-like segments. It includes earthworms and leeches.

CRUSTACEANS
Mainly aquatic, crustaceans are arthropods that breathe with gills. Classified as the subphylum Crustacea, there are about 70,000 species, including crabs and lobsters.

MOLLUSCS
One of the most diverse invertebrate groups, the phylum Mollusca contains almost 72,000 species. It includes gastropods, bivalves, and cephalopods.

ECHINODERMS
Recognizable by their five-fold symmetry, members of the phylum Echinodermata have a skeleton of small, chalky plates set in their skin. There are about 7,450 species.

SPONGES

Simple, mostly marine animals, adult sponges live permanently attached to rocks, corals, and shipwrecks. A few species live in fresh water.

The Porifera vary in size and shape, from thin sheets to huge barrels, but all have the same basic structure: different types of specialist cells, but no organs. A system of water canals branches through the sponge, and water is drawn into them through tiny pores in the sponge's surface. Special collar cells lining the water canals trap and engulf bacteria and other small plankton for food, and waste water exits through large openings called oscula.

Many sponges are classically "spongy", others are rock hard, soft, or even slimy depending on the supporting skeleton, which is made up of tiny spicules of silica or calcium carbonate. Spicules vary in shape and number between species and are an important feature in identification.

PHYLUM	PORIFERA
CLASSES	4
ORDERS	32
FAMILIES	144
SPECIES	More than 9,000

CALCAREOUS SPONGES

The skeleton of Calcarea is composed of densely packed, mostly star-like, calcium carbonate spicules, each with three or four pointed rays. Variable in shape and crunchy to the touch, most species are small and lobe- or tube-shaped.

8 cm
3¼ in

LEMON SPONGE
Leucetta chagosensis
F: Leucettidae
Growing on steep coral reefs in the W. Pacific, this sac-like sponge provides a splash of bright colour.

1–4 cm
⅜–1½ in

CLATHRINA CLATHRUS
F: Clathrinidae
Made up of many tubes, each only a few millimetres wide, this Mediterranean sponge is a distinctive yellow colour.

2–5 cm
1¾–2 in

PURSE SPONGE
Sycon ciliatum
F: Sycettidae
This simple, hollow sponge of N.E. Atlantic coasts has spiky calcareous spicules surrounding its osculum.

10 cm
4 in

8 cm
3¼ in

***LEUCONIA* SP.**
F: Baeriidae
The shape of this N.E. Atlantic sponge varies from lobes and cushions to crusts. It grows in areas of high water movement.

RED PURSE SPONGE
Grantessa sp.
F: Heteropiidae
Shaped like a small gourd, this delicate sponge grows between coral heads on shallow reefs in Malaysia and Indonesia.

DEMOSPONGES

More than eighty-five per cent of all sponges belong to the Demospongiae. Although they are varied in appearance, most have a skeleton made up of scattered silicon dioxide spicules and a flexible organic collagen called spongin. A few encrusting species have no skeleton and some have only spongin.

1 m
3¼ ft

BLUE SPONGE
Haliclona sp.
F: Chalinidae
One of very few blue-coloured sponges, this species commonly grows on the tops of corals and rocks off N. Borneo.

1 m
3¼ ft

BROWN TUBE SPONGE
Agelas tubulata
F: Agelasidae
This sponge consists of uneven brown tubes arranged in clusters. It is common on deep reefs in the Caribbean and Bahamas.

35 cm
14 in

MEDITERRANAEAN BATH SPONGE
Spongia (Spongia) officinalis
F: Spongiidae
This sponge has an elastic skeleton and no harsh scpicules so after it has been cleaned and dried, it is ideal for washing with.

5–10 cm
2–4 in

ELEPHANT HIDE SPONGE
Pachymatisma johnstonia
F: Geodiidae
Mounds of this tough sponge can cover large areas of rocks and wrecks in clear coastal waters of the N.E. Atlantic.

GOLF BALL SPONGE
Paratetilla bacca
F: Tetillidae
One of many tropical ball-shaped sponges, this species grows on sheltered coral reefs in the W. Pacific.

12 cm
4¾ in

30–40 cm
12–16 in

RED TREE SPONGE
Negombata magnifica
F: Podospongiidae
Attempts to farm this beautiful Red Sea sponge are meeting with some success. It contains chemicals of potential medical importance.

50 cm
20 in

BORING SPONGE
Cliona celata
F: Clionaidae

Although it appears as yellow lumps, much of this European sponge remains hidden as strands growing through shells and calcareous rocks.

15–30 cm
6–12 in

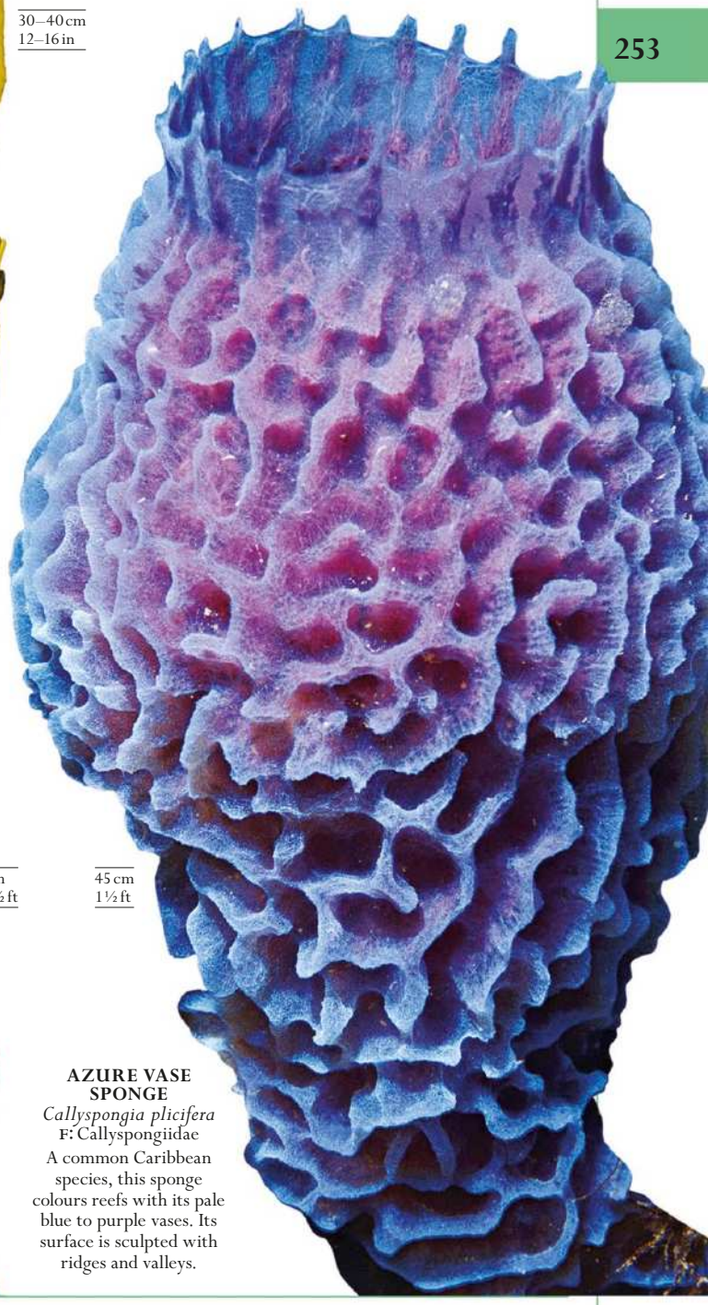
BORING SPONGE
Cliona delitrix
F: Clionaidae

Water leaves this Caribbean sponge via a number of large oscula (one is shown here). This sponge bores through corals by secreting acid.

30–40 cm
12–16 in

YELLOW FINGER SPONGE
Callyspongia (Callyspongia) nuda
F: Callyspongiidae

The bright colour of this tropical Pacific sponge is due to the chemicals it contains. Sponge extracts are used by the pharmaceutical industry.



45 cm
1½ ft

AZURE VASE SPONGE
Callyspongia plicifera
F: Callyspongiidae

A common Caribbean species, this sponge colours reefs with its pale blue to purple vases. Its surface is sculpted with ridges and valleys.

1 cm/⅜ in

BREADCRUMB SPONGE
Halichondria panicea
F: Halichondriidae

This N.E. Atlantic sponge grows as crusts on rocky shores and in shallow water. Its colour comes from symbiotic algae.

1–2 cm
⅜–¾ in

SPIRASTRELLA CUNCTATRIX
F: Spirastrellidae

One of many colourful encrusting sponges found in the ocean, this species covers inshore rocks in the Mediterranean and North Atlantic.

0.8–2 m
2½–6½ ft

APLYSINA ARCHERI
F: Aplysinidae

The graceful long tubes of this sponge sway gently with the current on the Caribbean reefs where it grows.

2 m/6½ ft

BARREL SPONGE
Xestospongia testudinaria
F: Petrosiidae

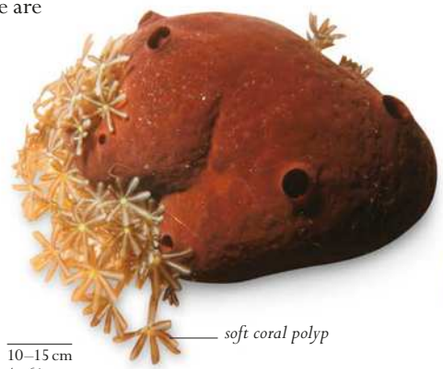
Small fish and many invertebrates live on and in this huge Indo-Pacific sponge, which grows big enough to fit a person inside.

HOMOSCLEROMORPHA SPONGES

This small class of just under 130 sponges is found in both temperate and tropical waters. They are mostly soft as they have tiny silica spicules or none at all. Their planktonic larvae are unique in form.

CHICKEN LIVER SPONGE
Plakortis lita
F: Plakinidae

The common name of this sponge reflects its look and feel. Dark brown inside and out and smooth to the touch, it is found on coral reefs in the W. Pacific.



10–15 cm
4–6 in

GLASS SPONGES

Hexactinellida are a small group of sponges that live mostly in the deep ocean, where some form reef-like mounds up to 20 m (65 ft) high. The six rayed, star-like, silica spicules of the skeleton are usually fused together as a rigid lattice. After death, the skeleton remains as a ghostly outline.

20 cm
8 in

BOLOSOMA GLASS SPONGE
Bolosoma sp.
F: Euplectellidae

Looking like fat fungi, *Bolosoma* sponges live in the deep sea and are held up into the water currents by a long, thin stalk.

35 cm
14 in

VENUS'S FLOWER BASKET
Euplectella aspergillum
F: Euplectellidae

Growing in tropical oceans below about 150 m (500 ft), this sponge was collected and displayed by Victorians for its delicate silica skeleton.

CNIDARIANS

This phylum includes jellyfish, corals, and anemones. They have stinging tentacles to catch live prey, which they digest in a simple sac-like gut.

All cnidarians are aquatic and most are marine. They have two body plans: a free-swimming, bell-like shape called a medusa – as seen in jellyfish – and a static polyp, typical of anemones. Neither medusae nor polyps have a head or front end. Their tentacles encircle a single gut opening, used to take in food and to eliminate waste.

A cnidarian's nervous system consists of a simple network of fibres; there is no brain. This means that the animal's behaviour is usually simple. Although they are carnivorous, cnidarians cannot actively pursue their prey, with the possible exception of the box jellyfish. Instead, most species wait for swimming animals to blunder into the reach of their tentacles.

STINGS

Cnidarians' outer skins – and in some species the inner skin as well – are peppered with tiny stinging capsules of a kind that is unique to animals of this phylum. These stinging organs are called cnidocysts (or cnidocytes), and it is from these that cnidarians get their name. Cnidocysts are concentrated on the tentacles, and are triggered by touch or chemical signals, both when the animal comes into contact with potential prey and when it is under attack. Each cnidocyst contains a microscopic sac of venom and discharges a tiny coiled "harpoon" to inject the venom into flesh. Some stings can penetrate human skin and inflict severe pain, but the vast majority of cnidarians are harmless to humans.

ALTERNATING LIFE CYCLE

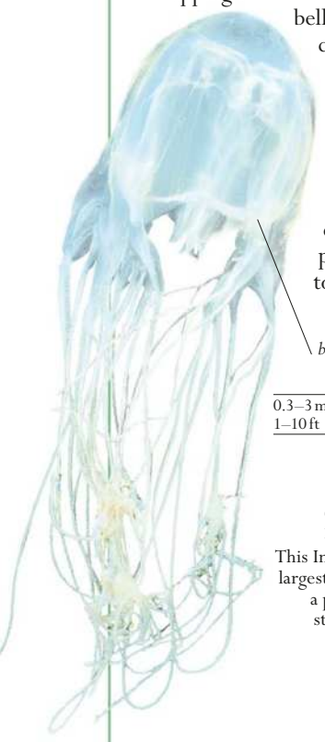
Many cnidarians have a life cycle that alternates between medusa and polyp – usually with one of these forms dominating, though in some groups one or other form is missing. The free-swimming medusa is normally the sexual stage. In most species fertilization is external: sperm and eggs are released in open water, forming planktonic planula larvae that resemble tiny flatworms. These settle in order to grow into polyps. Specialized polyps then produce new medusae to complete the cycle.

PHYLUM	CNIDARIA
CLASSES	6
ORDERS	22
FAMILIES	278
SPECIES	11,947

This microscopic view shows cnidocysts (stinging cells) that have been triggered to discharge their venom-laden harpoons.

BOX JELLYFISH

Members of the class Cubozoa are found in tropical and subtropical waters. They differ from true jellyfish in having a greater ability to control the direction and speed of their movement, rather than drifting with the currents. A flapping skirt at the bottom of the bell powers them at considerable speed. Box jellyfish have eyes, set in clusters on the sides of their transparent bell. They can see enough to steer past obstacles and to spot prey.

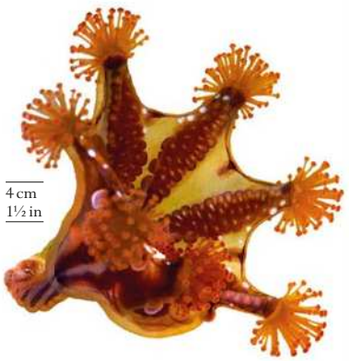


SEA WASP
Chironex fleckeri
F: Chirodropidae

This Indo-Pacific species – the largest box jellyfish – delivers a particularly painful sting and has caused human fatalities.

STALKED JELLYFISH

The adult is the only easily seen phase in the life cycle of members of the Class Staurozoa. Unlike other jellyfish it does not swim, but is attached to the substrate by a stalk. Eight arms radiate from the mouth, with clumps of tentacles at their tips. The other life stages are the extremely small planula larvae and polyps (called stauropolyps).



STALKED JELLYFISH
Haliclystus auricula
F: Haliclystidae

This species is found attached to algae and seagrasses in shallow cooler waters of the Atlantic and Pacific, where it catches food using stinging cells on the tentacles.

TRUE JELLYFISH

The familiar jellyfish bell is the medusa stage of the Scyphozoa life cycle. The polyp is reduced, or in some deep-sea forms, is missing. Jellyfish polyps undergo strobilation, a process that produces new tiny medusae by budding. Rhizostome jellyfish lack a fringe of tentacles around the bell.

MOON JELLYFISH
Aurelia aurita
F: Ulmaridae

This globally widespread genus has four long "arms" as well as small marginal tentacles. It swarms to breed near coasts and polyps settle in estuaries.

UPSIDE-DOWN JELLYFISH
Cassiopea andromeda
F: Cassiopeidae

Superficially resembling an anemone, this Indo-Pacific rhizostome jellyfish lives at the bottom of lagoons, mouth upwards, with its bell pulsating to circulate water.

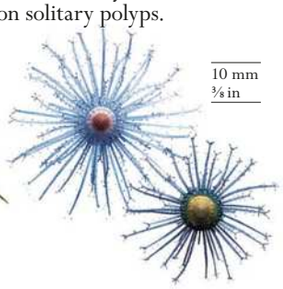
SPOTTED LAGOON JELLYFISH
Mastigias papua
F: Mastigiidae

Like other rhizostome jellyfish, this algae-containing species traps planktonic food with mucus. It enters South Pacific lagoons, including those of oceanic islands.

HYDROZOANS

Most animals of the class Hydrozoa live as branching sea-dwelling colonies forming miniature polyp-bearing forests. Some anchor themselves to surfaces by creeping horizontal stems, called stolons. Colonies are supported by a horny translucent sheath and some of the polyps produce sexual medusae. Freshwater hydra lack medusae: instead, sex organs develop directly on solitary polyps.

SNAILFUR
Hydractinia echinata
F: Hydractiniidae
One of a family of colonial spiny hydrozoans, this N.E. Atlantic species grows over the surface of snail shells containing hermit crabs.

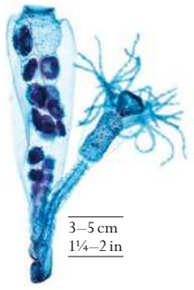


BLUE BUTTONS
Porpita porpita
F: Porpitidae
This colonial, jellyfish-like hydrozoan of tropical oceans is sometimes regarded as a highly modified individual polyp.

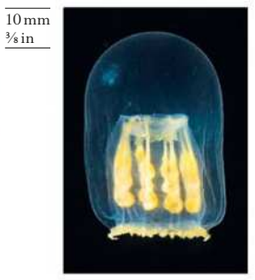
PURPLE LACE "CORAL" HYDROID
Distichopora violacea
F: Stylasteridae
Like some other hydrozoans, colonies of this Indo-Pacific lace coral have polyps specialized for different functions, such as feeding and stinging.

LION'S MANE JELLYFISH
Cyanea capillata
F: Cyaneidae
A large species of Arctic waters, this jellyfish has many tentacles arranged in dense groups. It has a powerful sting and its prey includes fish.

DEEP SEA CORONATE JELLYFISH
Periphylla periphylla
F: Periphyllidae
This is one of many little-known deep-water species in a group of jellyfish characterized by a bell with an encircling groove.



COMMON OBELIA
Obelia geniculata
F: Campanulariidae
This is a worldwide hydrozoan, abundant on intertidal seaweeds. It grows in zig-zag colonies of cup-encased polyps that sprout from creeping horizontal stems.



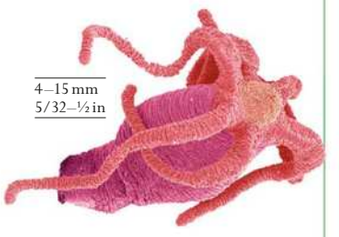
EIGHT-RIBBED HYDROMEDUSA
Melicertum octocostatum
F: Melicertidae
This hydrozoan from the North Atlantic and North Pacific oceans belongs to a family related to those with cup-encased polyps. It is known mainly from medusae.

CUP HYDROMEDUSA
Phialella quadrata
F: Phialellidae
Like related *Obelia*, branching colonies of this globally widespread hydrozoan release free-living medusae, which reproduce sexually.

PORTUGUESE MAN OF WAR
Physalia physalis
F: Physaliidae
Resembling a jellyfish, this is really an ocean-going colony of hydrozoans. Stinging tentacles and specialized polyps are suspended from a gas-filled float.

FEATHER HYDROID
Aglaophenia cupressina
F: Aglaopheniidae
Feather hydroids and the closely related sea ferns belong to a group of colonial hydrozoans with cup-encased polyps. This is an Indo-Pacific species.

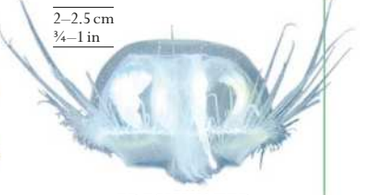
HULA SKIRT SIPHONPHORE
Physophora hydrostatica
F: Physophoridae
This widespread free-floating hydrozoan colony has a smaller float than its relative, the Portuguese man of war, and carries prominent swimming bells.



COMMON HYDRA
Hydra vulgaris
F: Hydridae
Lacking the medusa stage, hydras have small freshwater polyps that can reproduce asexually by budding. This is a globally widespread cold-water species, shown here in false colour.

PINK-HEARTED HYDROID
Tubularia sp.
F: Tubulariidae
Tubularia hydrozoans have polyps on long stems with two whorls of tentacles, one around the polyp base and one around its mouth.

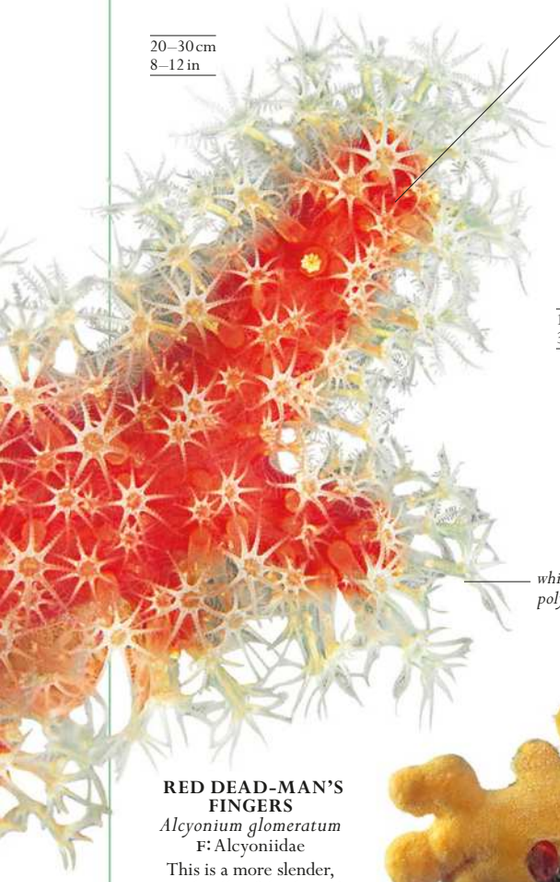
FIRE "CORAL" HYDROID
Millepora sp.
F: Milleporidae
Like others of its family, this fiercely stinging colonial hydrozoan has a calcified skeleton and is a reef-builder. It is distantly related to true stony corals.



FRESHWATER JELLYFISH
Craspedacusta sowerbii
F: Olindiidae
Sporadic in freshwater ponds, lakes, and streams worldwide, minute polyps of this animal develop into dominant medusae.

ANEMONES AND CORALS

Unlike other cnidarians, the Anthozoa lack the free-swimming medusa stage altogether and most remain static throughout their life cycle. The polyps, many of which have a flower-like appearance, produce sperm and eggs. Members of this class include solitary anemones, colonial sea pens, soft corals, and tropical reef-forming stony corals.

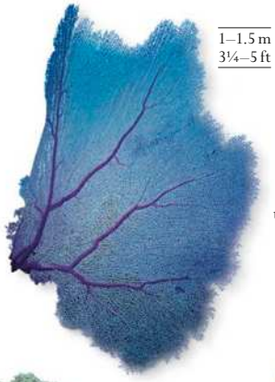


RED DEAD-MAN'S FINGERS
Alcyonium glomeratum
F: Alcyoniidae

This is a more slender, upright ally of dead-man's fingers, found on sheltered rocky European coastlines. It varies from yellow to red.

COMMON DEAD-MAN'S FINGERS
Alcyonium digitatum
F: Alcyoniidae

A typical soft coral, this thickly lobed European species has colonies of polyps, which are carried on a fleshy mass unsupported by a rigid skeleton.



COMMON SEA FAN
Gorgonia ventalina
F: Gorgoniidae

Sea fans, such as this Caribbean species, have upright fan-like colonies supported by a central axis, which is stiffened with a horny substance called gorgonin.

TOADSTOOL LEATHER CORAL
Sarcophyton trocheliophorum
F: Alcyoniidae

This soft coral can form enormous leathery colonies on tropical reefs of the Indo-Pacific. It is fast-growing, nourished by photosynthetic algae.

SEA STRAWBERRY
Gersemia rubiformis.
F: Nephtheidae

This stalked soft coral forms bright pink lumpy colonies. It occurs in northern parts of the Pacific and Atlantic Oceans.

CARNATION CORAL
Dendronephthya sp.
F: Nephtheidae

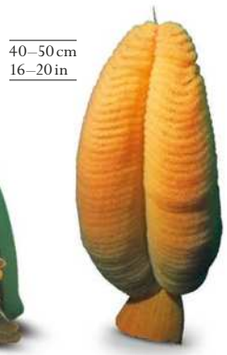
Typical of a family of stalked soft corals with polyps arranged in clusters, this colourful species occurs on Indo-Pacific tropical reefs.

RED CORAL
Corallium rubrum
F: Coralliidae

Colonies of this Mediterranean sea fan (not a true coral) are supported by a skeleton of tiny, enmeshed calcified needles. It is valued for jewellery.

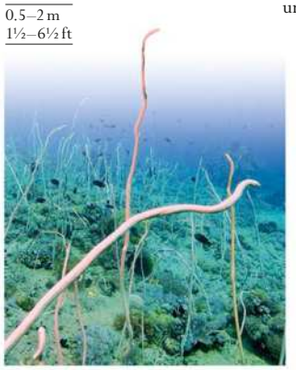
KIDNEY SEA PEN
Sarcoptilus grandis
F: Pennatulidae

Widespread in temperate-waters, this sea pen has kidney-shaped branches that occur in rows along each side of its body.



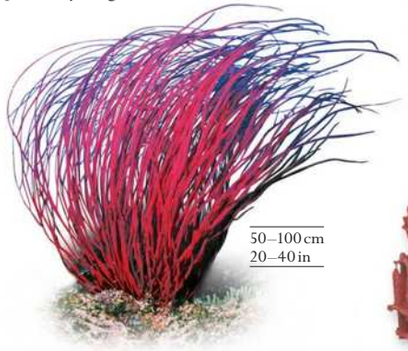
ORANGE SEA PEN
Ptilosarcus gurneyi
F: Pennatulidae

One of many brightly coloured sea pens, this species from the Pacific coast of N. America retracts into its burrow when disturbed by predators.



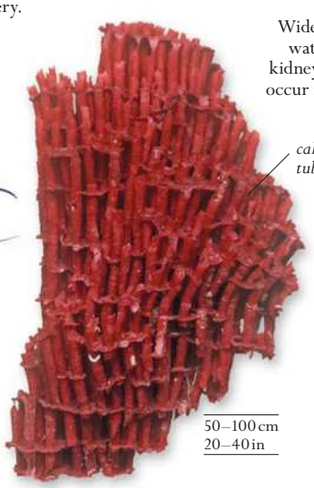
WHITE SEA WHIP
Junceella fragilis
F: Ellisellidae

Sea whips are thread-like relatives of sea fans, with their supporting horny axis reinforced with calcium. This is an Indonesian reef species.



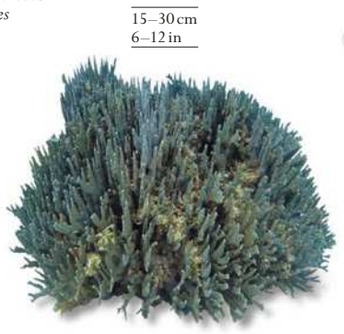
RED SEA WHIP
Ellisella sp.
F: Ellisellidae

Ellisella sea whips form two-prong branching colonies, some of which may form dense underwater bushes.They occur in tropical and temperate waters.



ORGAN PIPE CORAL
Tubipora musica
F: Tubiporidae

This Indo-Pacific soft coral has polyps in upright, calcified tubes, which are connected to the colony by a root-like network at the base.



BLUE CORAL
Heliopora coerulea
F: Helioporidae

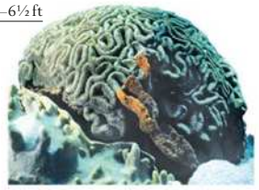
Despite its hard, calcified skeleton, this species is more closely related to soft coral than stony coral. It is the only member of its order.

10–20 cm
4–8 in

FLOWERPOT CORAL
Goniopora columna
F: Poritidae
This species has daisy-like polyps that are greatly lengthened when fully extended. It is an Indo-Pacific relative of the lobe coral.

4–5 m
13–16 ft

LOBE CORAL
Porites lobata
F: Poritidae
One of the commonest reef-builders of the Indo-Pacific, this coral forms large encrusting colonies in places buffeted by strong wave action.


1–2 m
3¼–6½ ft

LOBED BRAIN CORAL
Lobophyllia sp.
F: Lobophylliidae
Massive colonies of this brain coral – either flattened or dome-shaped – occur on reefs in tropical waters of the Indo-Pacific.

10–12 cm
4–4¾ in

DAHLIA ANEMONE
Urticina felina
F: Actiniidae
Sticky swellings on this anemone may carry so much debris that, with tentacles retracted, it resembles a small pile of gravel. It occurs around the North Pole.

1–3 m
3¼–9¾ ft

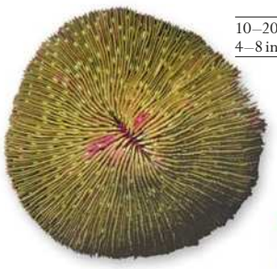
STAGHORN CORAL
Acropora sp.
F: Acroporidae
The branching stag horn corals are among the largest tropical reef-builders. Nourished by photosynthetic algae, these species are fast growing.

1 m
3¼ ft

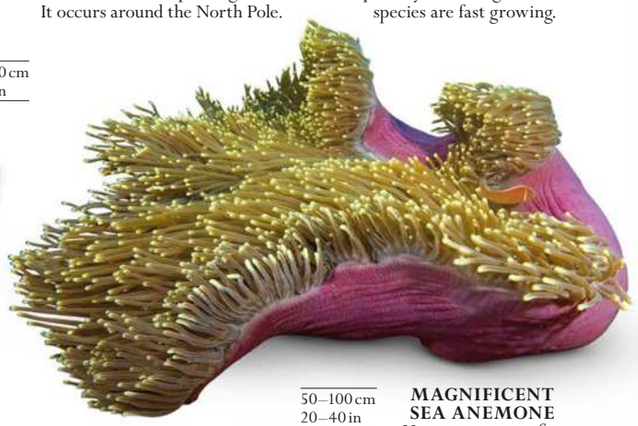
DAISY CORAL
Goniopora sp.
F: Poritidae
Long-reaching polyps of *Goniopora* stony corals on tropical reefs typically have 24 tentacles. They are among the most flower-like of corals.

1–3 m
3¼–10 ft

LARGE-GROOVED BRAIN CORAL
Colpophyllia sp.
F: Faviidae
The hemispherical brain-like structure of this coral is typical of its family. It is a tropical reef-builder that contains photosynthetic algae.


10–20 cm
4–8 in

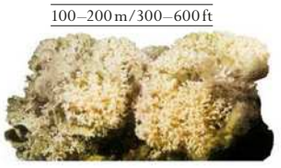
MUSHROOM CORAL
Fungia fungites
F: Fungiidae
This is one of many tropical mushroom corals that are not reef-building, but live among other species as solitary polyps crawling over the ocean floor.


50–100 cm
20–40 in

MAGNIFICENT SEA ANEMONE
Heteractis magnifica
F: Stichodactylida
This giant anemone is from Indo-Pacific reefs, where it lives in close partnership with a variety of fish species, including clown fish.

10–15 mm
⅜–½ in

DEVONSHIRE CUP CORAL
Caryophyllia (Caryophyllia) smithii
F: Caryophylliidae
This N. E. Atlantic species belongs to a family containing cold water corals, some with large, anemone-like polyps. Barnacles frequently attach to it.


100–200 m/300–600 ft

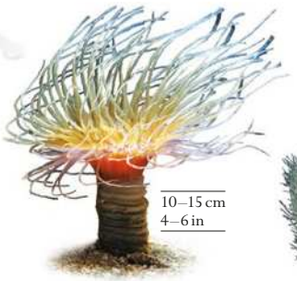
ATLANTIC COLD WATER CORAL
Desmophyllum pertusum
F: Caryophylliidae
Unlike many deep sea corals lacking nutrient-supplying algae, this North Atlantic species forms extensive reefs, although only very slowly.

2.5–15 cm
1–6 in

PLUMOSE ANEMONE
Metridium senile
F: Metridiidae
This is a globally widespread member of a family of anemones that is characterized by a fuzzy mass of tentacles. It can split to form genetically identical populations.

5–7 cm
2–2¾ in

SNAKELOCKS ANEMONE
Anemonia viridis
F: Actiniidae
The conspicuously long tentacles of this common European intertidal anemone rarely retract, even when exposed at low tide.


10–15 cm
4–6 in

COMMON TUBE ANEMONE
Cerianthus membranaceus
F: Cerianthidae
Tube anemones burrow through sediment, using unique non-stinging cnidocysts to build felt-like tubes from mucus. This species occurs on European offshore mud.

50–100 cm
20–40 in

ATLANTIC BLACK CORAL
Antipathes sp.
F: Antipathidae
Mostly found in deep waters, black corals consist of spiny polyp colonies encased in slender, horny exoskeletons.

FLATWORMS

Structurally among the simplest of animals, flatworms live wherever a moist habitat can provide their thin, flat body with oxygen and food.

Platyhelminthes, commonly known as flatworms, are a major phylum of animals found in various forms in the ocean, in freshwater ponds, or even within the bodies of other animals. Superficially resembling leeches, flatworms are in fact far simpler animals. With no blood system and no organs for breathing, they use their entire body surface to absorb oxygen and release carbon dioxide. Flatworm species that have no gut also absorb their food in this way. In other species the gut has one opening but branches frequently, so that digested food can still reach all tissues, even without a blood stream to circulate the nutrients. Some free-living flatworms are detritus-eaters, gliding along on a bed of microscopic beating hairs. Others prey on other invertebrates.

INTERNAL PARASITES

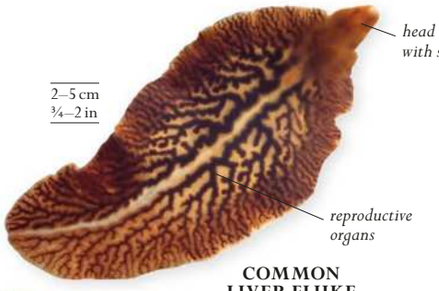
Tapeworms and flukes are parasites. Inside the host animal, their flattened body is perfectly suited for absorbing nutrients. Many have complex ways of passing from host to host and may infect more than one type of animal. They enter the body of the host in infected food or sometimes by penetrating the skin. Once inside, a parasite may go deeper into the body – burrowing through the gut wall to lodge in vital organs.

PHYLUM	PLATYHELMINTHES
CLASSES	6
ORDERS	41
FAMILIES	About 420
SPECIES	About 30,000

DEBATE

A NEW PHYLUM?

Traditionally, the tiny, gutless, and brainless marine animals called acoels are viewed as flatworms. Controversial studies suggest that they belong in a new phylum of their own, and that they are the most primitive living animals to show bilateral symmetry – in contrast to radial (round) cnidarians.



2–5 cm
¾–2 in

COMMON LIVER FLUKE
Fasciola hepatica
F: Fasciolidae

Flukes typically have complex, parasitic life cycles. This species infects grass-eating sheep or cattle via freshwater snails, and feeds from the host's liver.

GIANT INTESTINAL FLUKE
Fasciolopsis buski
F: Fasciolidae

This E. Asian species is one of the largest flukes to infect humans. It lives only in the upper intestine and does not enter other organs.

7.5 cm
3 in

2–7 m
6½–23 ft

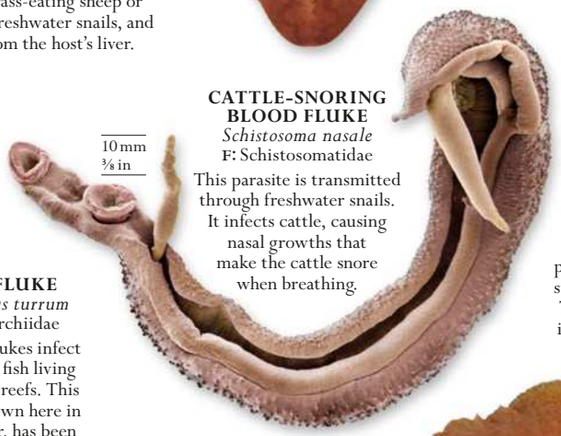
PORK TAPEWORM
Taenia solium
F: Taeniidae

Tapeworms are intestinal parasites, but at an intermediate stage can invade muscle as cysts. This species' intermediate host is pigs, and may pass to humans in infected meat.

5–6 mm
3/16–¼ in

JACK FLUKE
Provitellus turrum
F: Monorchiidae

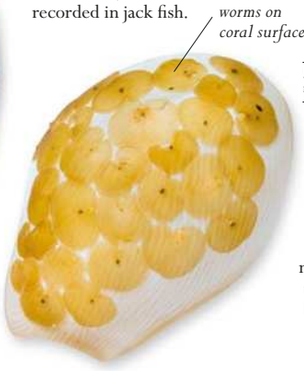
Provitellus flukes infect the guts of fish living on tropical reefs. This species, shown here in false colour, has been recorded in jack fish.



10 mm
⅜ in

CATTLE-SNORING BLOOD FLUKE
Schistosoma nasale
F: Schistosomatidae

This parasite is transmitted through freshwater snails. It infects cattle, causing nasal growths that make the cattle snore when breathing.



5 mm
3/16 in

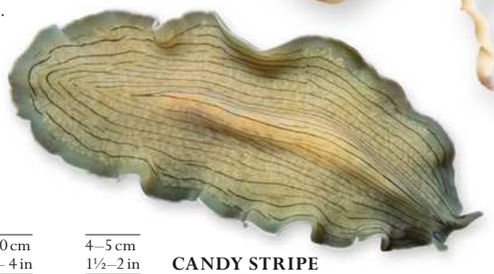
EPIZOIC FLATWORM
Waminoa sp.
F: Convolutidae

This coral-living species is one of many marine micro-flatworms that resemble planktonic larvae of cnidarians.

8–10 cm
3¼–4 in

GIANT LEAF FLATWORM
Kaburakia excelsa
F: Stylochidae

Like other leaf flatworms, this N. American intertidal species is mainly carnivorous. It smothers its prey with a mouth-bearing extension of its gut.



4–5 cm
1½–2 in

CANDY STRIPE FLATWORM
Prosthecereaus vittatus
F: Euryleptidae

This animal belongs to a group of mainly marine, free-living, cross-fertilizing hermaphrodites called polyclads. It is an Atlantic Ocean species.

ROUNDWORMS

The simple, cylindrical roundworms are remarkably successful – surviving almost everywhere, resisting drought, and reproducing rapidly.

PHYLUM	NEMATODA
CLASSES	2
ORDERS	17
FAMILIES	About 160
SPECIES	About 26,000

The phylum Nematoda is ubiquitous. There can be millions of roundworms in a square metre of soil, and they also live in freshwater or marine habitats. Many are parasites. These worms, or nematodes, can be extraordinarily prolific, producing hundreds of thousands of eggs per day. When environmental conditions deteriorate they can survive heat, frost, or drought by producing resistant stages and becoming dormant.

Roundworms have a muscle-lined body cavity and two openings to their gut – the mouth and anus. Their cylindrical body is coated in a tough layer, called a cuticle – functionally similar to that of arthropods – which they moult periodically as they grow.

BLACK AND YELLOW FLATWORM
Pseudoceros dimidiatus
F: Pseudocerotidae

Marine polyclads are large free-living flatworms. Many are strikingly coloured, warning predators of their nasty taste. This species is from Indo-Pacific waters.

7–8 cm
2¾–3¼ in

undulating margin

4–9 cm
1½–3½ in

SHOVEL-HEADED LAND FLATWORM
Bipalium kewense
F: Bipaliidae

Land flatworms are mostly tropical and need damp conditions. This Asian species has been accidentally introduced to greenhouses around the world.

20–30 cm
8–12 in

FLOWERS' FLATWORM
Pseudobiceros flowersi
F: Pseudocerotidae

Like many reef-dwelling polyclads, this Indo-Pacific species glides with an undulating margin. It has been found under rubble in lagoons.

7–8 cm
2¾–3¼ in

GOLD-SPECKLED FLATWORM
Thysanozoon nigropapillosum
F: Pseudocerotidae

Many *Thysanozoon* polyclads are coated with pimply swellings, which are yellow-tipped on this otherwise velvety black species of the Indo-Pacific.

1.5–2 cm
½– ¾ in

DRAB FRESHWATER FLATWORM
Dugesia lugubris
F: Planariidae

Triclads are flatworms with a triple-branched gut. This European species is one of many triclads found in freshwater habitats; others are marine.

10–17 cm
4–6½ in

NEW ZEALAND LAND FLATWORM
Arthurdendyus triangulatus
F: Geoplanidae

This large soil-living species is native to New Zealand, but has invaded Europe. It preys on earthworms.

1–1.5 cm
⅜–½ in

BROWN FRESHWATER FLATWORM
Dugesia tigrina
F: Planariidae

This species is native to freshwater habitats of N. America, but has been introduced to Europe.

2–3 cm
¾–1¼ in

STREAM FLATWORM
Dugesia gonocephala
F: Planariidae

Many of the freshwater *Dugesia* flatworms, such as this European species of running water, have ear-like flaps for detecting water currents.

7–11 mm
7/32–½ in

stained green

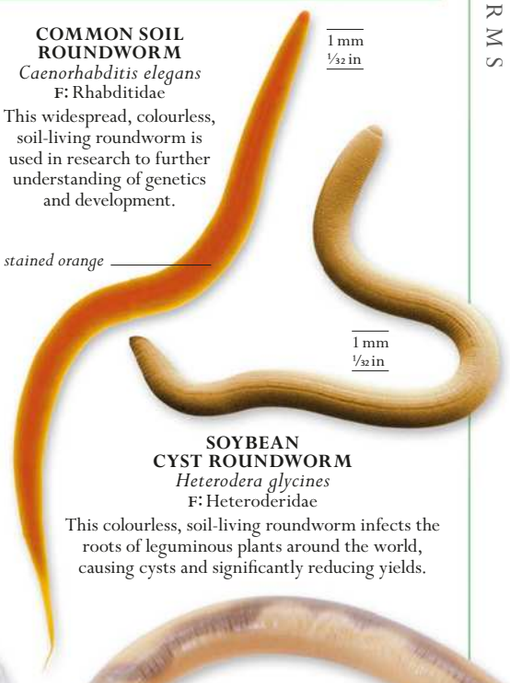
NEW WORLD HOOKWORM
Necator americanus
F: Uncinariidae

Hookworm larvae penetrate skin and travel in the blood to the lungs of the host. They crawl to the throat, are swallowed, and mature in the gut. This species, shown here in false colour, parasitizes humans, dogs, and cats.

3–5 cm
1¼–2 in

COMMON WHIPWORM
Trichuris trichiura
F: Trichuridae

Like many other gut parasites, the mainly tropical whipworm infects humans who eat food contaminated with faeces. It completes its life cycle in the intestines.



1 mm
1/32 in

COMMON SOIL ROUNDWORM
Caenorhabditis elegans
F: Rhabditidae

This widespread, colourless, soil-living roundworm is used in research to further understanding of genetics and development.

stained orange

1 mm
1/32 in

SOYBEAN CYST ROUNDWORM
Heterodera glycines
F: Heteroderidae

This colourless, soil-living roundworm infects the roots of leguminous plants around the world, causing cysts and significantly reducing yields.

15–35 cm
6–14 in

LARGE INTESTINAL ROUNDWORM
Ascaris lumbricoides
F: Acarididae

A common parasite of humans in regions of poor sanitation where people get infected by eating food contaminated with faeces, with adult worms then living in the host intestine.

SEGMENTED WORMS

With more complex muscle and organ systems than flatworms, many species of this phylum, called Annelida, are accomplished swimmers or burrowers.

Segmented worms include earthworms, ragworms, and leeches. For most, their blood circulates in vessels and they have a firm sac of fluid (the coelom) running the length of their body, which keeps motion of the gut separate from motion of the body wall. The coelom is split into sections, with each one corresponding to a body segment. Each body segment contains a set of muscles, and coordination of these muscle sets can send a wave of contraction down the length of the body, or make it flex to and fro. This makes many annelids highly mobile both on land and in the water.

Marine segmented worms – the predatory ragworms and their filter-feeding relatives – carry bundles of bristles along their body, typically borne on little paddles that help with swimming, burrowing, or even walking. This group of bristled, segmented worms are called polychaetes or bristle worms.

Land-living earthworms are more sparsely bristled detritus-feeders, and are important recyclers of dead vegetation and aerators of soil. Many leeches are specialized further, and carry suckers to extract blood from a host. Their saliva contains chemicals that stop blood clotting. Other leeches are predatory. Both earthworms and leeches have a saddle-shaped, glandular structure around their body called a clitellum, which they use to make their egg cocoons.

PHYLUM	ANNELIDA
CLASSES	4
ORDERS	17
FAMILIES	About 130
SPECIES	About 18,000

SLUDGE WORM
Tubifex sp.
F: Naididae
This widely distributed worm can be seen in mud polluted by sewage, the front end buried, the rear end wiggling to extract oxygen.

MEGADRILE EARTHWORM
Glossoscolex sp.
F: Glossoscolecidae
Glossoscolex are large earthworms from tropical C. and S. America. Many are found in rainforest habitats.

TIGER WORM
Eisenia foetida
F: Lumbricidae
This European inhabitant of rotting vegetation secretes defensive pungent fluid and, like other earthworms, has a "saddle" for producing cocoons of eggs.

COMMON EARTHWORM
Lumbricus terrestris
F: Lumbricidae
This earthworm – native to Europe but introduced elsewhere – drags leaves into its burrow at night as a source of food.

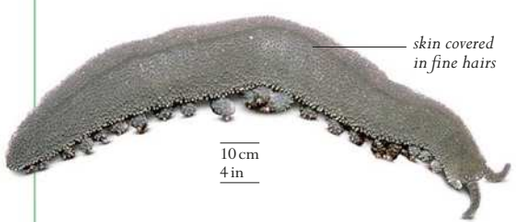
CHRISTMAS TREE TUBE WORM
Spirobranchus giganteus
F: Serpulidae
Characterized by its spiral whorls of tentacles, used for filter feeding and extracting oxygen, this species is widespread on tropical reefs.

VELVET WORMS

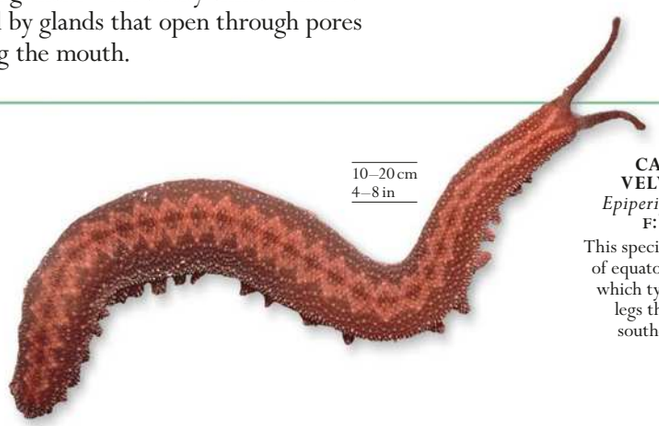
These soft-bodied worms, cousins of arthropods, lumber slowly along dark forest floors like giant caterpillars, but they are extraordinary hunters.

These animals have the body of an earthworm and the multiple limbs of a millipede, but belong in a phylum of their own: Onychophora. Velvet worms are rarely seen in their warm native rainforests of tropical America, Africa, and Australasia; they shun the open, preferring to hide in crevices and leaf litter. They come out at night or after rainfall to hunt other invertebrates. Velvet worms capture their prey in a unique way: they immobilize their victims by spraying them with sticky slime which is produced by glands that open through pores straddling the mouth.

PHYLUM	ONYCHOPHORA
CLASS	1
ORDER	1
FAMILIES	2
SPECIES	About 200



SOUTHERN AFRICAN VELVET WORM
Peripatopsis moseleyi
F: Peripatopsidae
This species belongs to a family with a globally southern distribution.



CARIBBEAN VELVET WORM
Epiperipatus broadwayi
F: Peripatidae
This species is one of a family of equatorial velvet worms, which typically have more legs than those of the southern continents.

6–30 cm
2¼–12 in

FIRE WORM
Hermodice carunculata
F: Amphinomidae

A tropical Atlantic offshore species, this polychaete preys on corals, sucking out the soft flesh from the hard skeleton. Its body extensions have painfully irritating bristles.

10–20 cm
4–8 in

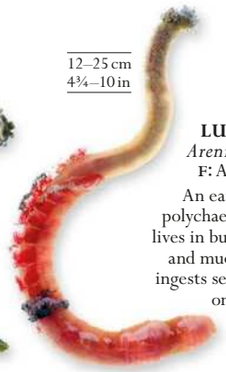
SEA MOUSE
Aphrodita aculeata
F: Aphroditidae

This mud-burrowing scale worm is found in the shallow waters of N. Europe. Its scales are covered with a hair-like coat.

2.5–3 cm
1–1¼ in

SEA CUCUMBER SCALE WORM
Gastrolepidia clavigera
F: Polynoidea

This Indo-Pacific polychaete has flattened back scales. It is parasitic on sea cucumbers.



12–25 cm
4¾–10 in

LUGWORM
Arenicola marina
F: Arenicolidae

An earthworm-like polychaete, the lugworm lives in burrows on beaches and mud-flats, where it ingests sediment and feeds on detritus.

1–4 m
3¼–13 ft

HONEYCOMB WORM
Sabellaria alveolata
F: Sabellaridae

This tubeworm builds its tubes from sand and shell fragments. Dense populations form honeycomb-like reefs in the Atlantic and Mediterranean.

5–15 cm
2–6 in

GREEN PADDLE WORM
Eulalia viridis
F: Phyllodocidae

Paddleworms are active carnivores with leaf-shaped flaps on their body extensions. This European species lives among intertidal rocks and kelp.

8–10 cm
3¼–4 in

PACIFIC FEATHERDUSTER WORM
Sabellastarte sanctijosephi
F: Sabellidae

A tropical Indo-Pacific tubeworm, this species is common along coastlines, including coral reefs and tidal pools.

25–40 cm
10–16 in

KING RAGWORM
Alitta virens
F: Nereididae

Ragworms, close relatives of paddleworms, have two-pronged body extensions. This Atlantic mud-burrowing species can deliver a painful bite.

5–7 cm
2–2¾ in

RED TUBE WORM
Serpula vermicularis
F: Serpulidae

Serpulid tubeworms build hard chalky tubes. Like most serpulids, this widespread species has tentacles modified to plug the tube after retraction.

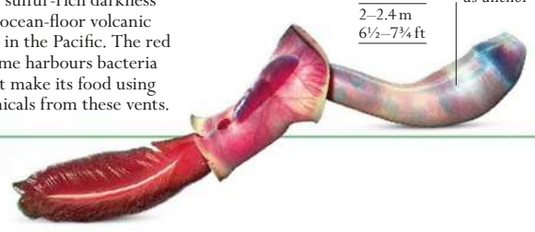
2–3 mm
1/16–⅛ in

NORTHERN SPIRAL TUBE WORM
Spirorbis borealis
F: Serpulidae

The small coiled tube of this tubeworm is cemented to brown *Fucus* seaweeds and kelps along North Atlantic coastlines.

GIANT TUBE WORM
Riftia pachyptila
F: Siboglinidae

This tubeworm lives in the hot sulfur-rich darkness of ocean-floor volcanic vents in the Pacific. The red plume harbours bacteria that make its food using chemicals from these vents.



2–2.4 m
6½–7¾ ft

body used as anchor

WATER BEARS

Visible only through a microscope, stubby-legged, agile water bears share their aquatic community with microbes and far simpler invertebrates.

Tiny water bears, or tardigrades (meaning "slow-stepped") clamber through miniature forests of water weed, four pairs of short legs clinging on with clawed feet. Most are less than a millimetre long. They abound among moss or algae, where many use their needle-like jaws to pierce the cells of this vegetation and suck its sap. Many water bear species are known only as females, which reproduce asexually by spawning offspring from unfertilized eggs. If its habitat dries up, a water bear is able to survive by going into a kind of suspended animation called cryptobiosis, shrivelling into a husk, sometimes for years at a time, until rainfall revives it.

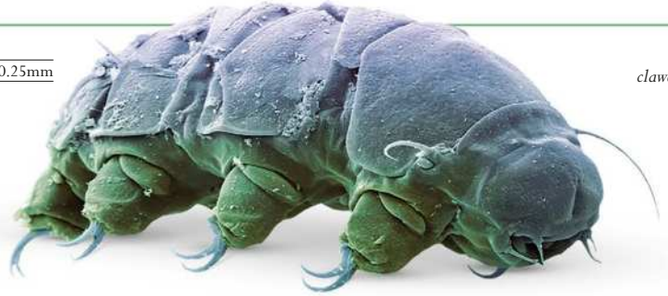
PHYLUM	TARDIGRADA
CLASSES	3
ORDERS	5
FAMILIES	20
SPECIES	About 1,000

clawed feet

0.25 mm

SEAWEED WATER BEAR
Echiniscoides sigismundi
F: Echiniscoididae

One of many little-known marine water bears, this species has been recorded among seaweed in coastal locations around the world.



0.25 mm

MOSS WATER BEAR
Echiniscus sp.
F: Echiniscidae

Many water bears live in moss, but their ability to survive in a dried state has helped a number of species to disperse worldwide.

ARTHROPODS

Jointed legs and flexible armour have helped a phylum that includes winged insects and underwater crustaceans to evolve unrivalled diversity.

There are more species of arthropods known to scientists than all the other animal phyla added together – and doubtless many more await discovery. They have an extraordinary range of lifestyles including grazing, predation, filtering particles of food in water, and drinking fluids such as nectar or blood.

Arthropods are coated by an exoskeleton made of a tough material called chitin. It is sufficiently flexible around the joints and between segments to allow for mobility, but resists stretching. As arthropods grow, they must periodically moult their exoskeleton, which is replaced by a slightly larger one. The exoskeleton serves as protective armour but also helps reduce water loss in very dry habitats.

BODY PARTS

Arthropods evolved from a segmented ancestor, perhaps a worm-like creature. Body segmentation persists in all arthropods, but is especially obvious in millipedes and centipedes. In other groups, various segments have fused together into discrete body sections. Insects are divided into a sensory head, a muscular thorax with legs and wings, and an abdomen containing most of the internal organs. In arachnids and some crustaceans, the head and thorax are fused into one single section.

GETTING OXYGEN

Aquatic arthropods, such as crustaceans, breathe with gills. The bodies of most land arthropods – insects and myriapods – are permeated by a network of microscopic, air-filled tubes called tracheae. These open out through pores known as spiracles on the sides of the body, usually one pair per body section. Small muscles inside the spiracles regulate the flow of air by means of valves. In this way, oxygen can reach all cells of the body and does not need to be transported in blood. Some arachnids breathe with tracheae; others with book lungs in their abdomen that evolved from the gills of their aquatic ancestors. Most use a combination of the two.

PHYLUM	ARTHROPODA
CLASSES	19
ORDERS	123
FAMILIES	About 2,300
SPECIES	About 1.2 million

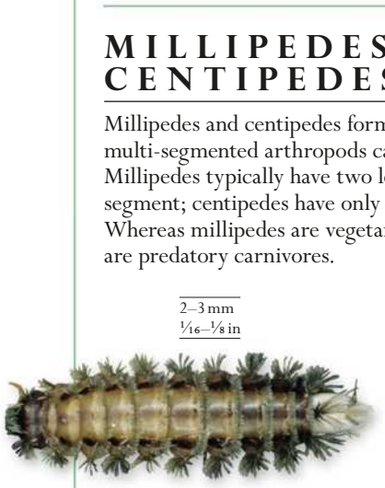
DEBATE

CAMOUFLAGE AND MIMICRY

Many arthropods have adapted to their environment by blending imperceptibly into it. Stick insects, for example, look so like twigs that they are very difficult for predators to spot. In contrast, arthropods, such as wasps, have evolved bright colours that warn others they are distasteful or dangerous. The hornet moth is completely harmless but avoids predation because it looks and sounds exactly like a hornet. Despite their similar appearance, other anatomical features separate them into different orders. The hornet moth belongs to the order Lepidoptera and the hornet to the order Hymenoptera.

MILLIPEDES AND CENTIPEDES

Millipedes and centipedes form a group of multi-segmented arthropods called myriapods. Millipedes typically have two legs per body segment; centipedes have only one per segment. Whereas millipedes are vegetarian, centipedes are predatory carnivores.



2–3 mm
1/16–1/8 in

BRISTLY MILLIPEDE
Polyxenus lagurus
F: Polyxenidae
One of a family of millipedes armed with defensive bristles, this tiny species of the northern hemisphere lives under the bark of trees and in leaf litter.

1–2 cm
3/8–3/4 in

AMERICAN SHORT-HEADED MILLIPEDE
Brachycybe sp.
F: Andrognathidae
This is a N. American representative of a family of small, flat millipedes that live in rotting wood and leaf litter.

BROWN GIANT PILL MILLIPEDE
Zephronia sp.
F: Zephroniidae
Giant pill millipedes, such as this Bornean species, differ from their smaller northern hemisphere relatives in that they have 13 body sections rather than 12.

3–4 cm
1¼–1½ in

BLACK GIANT PILL MILLIPEDE
Zoosphaerium sp.
F: Sphaerotheriidae
One of many southern hemisphere giant pill millipedes, this species is native to Madagascar.

WHITE-RIMMED PILL MILLIPEDE
Glomeris marginata
F: Glomeridae
Pill millipedes, such as this European species, have fewer body segments than other millipedes and can roll into a ball when disturbed.

2–6 cm
¾–2¼ in

BLACK SNAKE MILLIPEDE
Tachypodoiulus niger
F: Julidae

Unlike its close relatives, this distinctive, white-legged millipede from W. Europe spends much time above ground – even climbing trees and walls.

7.5–13 cm
3–5 in

AMERICAN GIANT MILLIPEDE
Narceus americanus
F: Spirobolidae

This large, Atlantic coast millipede belongs to a family of mainly American, cylindrical millipedes. Like its relatives, it releases noxious chemicals in defence.

1.5–3 cm
½–1¼ in

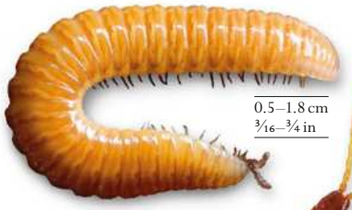
BROWN SNAKE MILLIPEDE
Julus scandinavius
F: Julidae

A member of a large family of cylindrical millipedes with ring-encased segments, this species occurs in European deciduous woodland, especially on acid soils.

20–38 cm
8–15 in

AFRICAN GIANT MILLIPEDE
Archispirostreptus gigas
F: Spirostreptidae

One of the largest of all millipedes, this species occurs mainly in tropical E. Africa and is one of many species that release irritating chemicals to defend themselves.



0.5–1.8 cm
3/16–¾ in

BORING MILLIPEDE
Polyzonium germanicum
F: Polyzoniidae

This somewhat primitive millipede has a scattered distribution in Europe. It lives in woodland and resembles beech bud scales when coiled.

1.5–6 cm
½–2¼ in

EASTERN FLAT-BACKED MILLIPEDE
Polydesmus complanatus
F: Polydesmidae

Polydesmids have projections on their exoskeleton that make them look flat-backed. This E. European species is a fast runner.

2–4.5 cm
¾–1¾ in

YELLOW EARTH CENTIPEDE
Geophilus flavus
F: Geophilidae

Eyeless geophilids have more segments (and therefore legs) than other centipedes. This European soil-dweller has been introduced to the Americas and Australia.

4–6 cm
1½–2¼ in

TANZANIAN FLAT-BACKED MILLIPEDE
Coromus diaphorus
F: Oxydesmidae

The shiny pitted surface typical of many of the eyeless flat-backed millipedes is especially prominent in this species from tropical Africa.

2–3 cm
¾–1¼ in

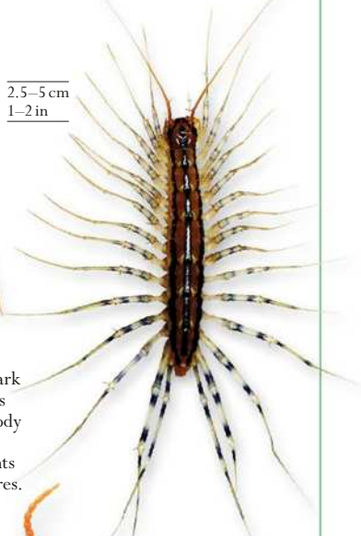
BROWN STONE CENTIPEDE
Lithobius forficatus
F: Lithobiidae

Found sheltering beneath bark and rock, stone centipedes characteristically have 15 body segments. This globally widespread species frequents forests, gardens, and seashores.

2–3 cm
¾–1¼ in

BANDED STONE CENTIPEDE
Lithobius variegatus
F: Lithobiidae

Once thought to be confined to Britain, this centipede is now known in continental Europe, where native populations have unbanded legs.



2.5–5 cm
1–2 in

HOUSE CENTIPEDE
Scutigera coleoptrata
F: Scutigeridae

An unmistakable centipede, this long-legged animal with compound eyes is one of the fastest invertebrate runners. Native to the Mediterranean region, it has been introduced elsewhere.

20–25 cm
8–10 in

"fangs" inject venom

one pair of legs per body segment

TIGER GIANT CENTIPEDE
Scolopendra hardwickei
F: Scolopendridae

Many of the giant *Scolopendra* centipedes have vibrant warning colours. This Indian species is one of several with a "tiger" pattern.

10–15 cm
4–6 in

BLUE-LEGGED CENTIPEDE
Ethmostigmus trigonopodus
F: Scolopendridae

This close relative of the giant *Scolopendra* centipedes is widespread throughout Africa and is one of several species with blue-tinted legs.

ARACHNIDS

A class within the phylum Arthropoda, arachnids include predatory spiders and scorpions, as well as mites and blood-sucking ticks.

Arachnids and related horseshoe crabs are chelicerates – arthropods named for their claw-like mouthparts (chelicerae). The head and thorax of chelicerates are fused into one body section, which carries the sensory organs, brain, and four pairs of walking legs. Unlike other arthropods, chelicerates lack antennae.

EFFECTIVE PREDATORS

Scorpions, spiders, and their relatives are land-living predators that have evolved quick ways of immobilizing and killing prey. Spiders use their chelicerae as fangs to inject venom and many first ensnare prey by spinning webs. Scorpions inject venom with the sting in their tail. Between their legs and chelicerae, arachnids also have a pair of limb-like pedipalps. These are modified into grasping pincers in scorpions or sperm-transferring clubs in male spiders.

MICROSCOPIC DIVERSITY

Many mites are too small to see with the naked eye. They abound in almost every habitat, where they scavenge on detritus, prey on other tiny invertebrates, or live as parasites. Some lead innocuous lives in skin follicles, feathers, or fur; others cause disease or allergy. One group – the ticks – are blood-suckers and can spread disease-causing microbes.

PHYLUM	ARTHROPODA
CLASS	ARACHNIDA
ORDERS	12
FAMILIES	661
SPECIES	About 103,000

This female wasp spider waits at the centre of her dewy orb web to ensnare any insect prey that might fly in.

4–5 cm
1½–2 in

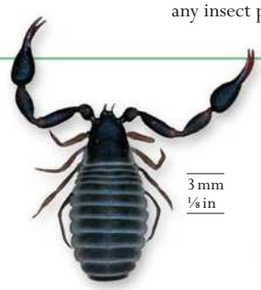
CHILEAN BURROWING SCORPION
Centromachetes pococki
F: Bothriuridae

A burrowing scorpion from the southern hemisphere, this species occurs in temperate forests in S. America, often under rotting logs.

3 mm
⅛ in

MARITIME PSEUDOSCORPION
Neobisium maritimum
F: Neobisiidae

A common W. European coastal pseudoscorpion, this species lives under stones and seaweed in the splash and upper intertidal zones.



3 mm
⅛ in

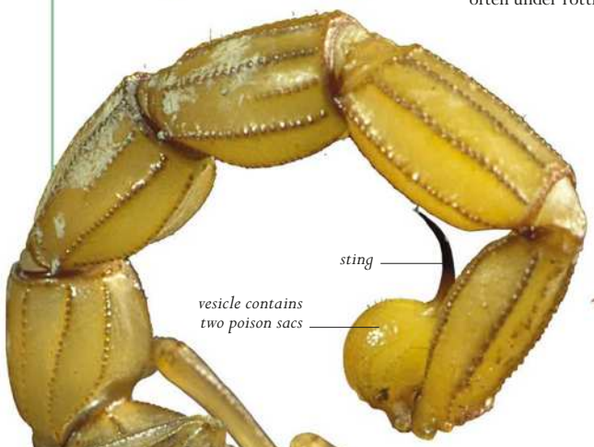
FINGER-CLAWED PSEUDOSCORPION
Dactylochelifer latreillei
F: Cheliferidae

Pseudoscorpions are tiny arachnids that kill their prey with venomous pincers. This European species lives at the base of seashore grasses.

1.5–2.5 mm
1/16–⅛ in

BROAD-HEADED PSEUDOSCORPION
Chthonius ischnocheles
F: Chthoniidae

Pseudoscorpions, such as this European species, sometimes find small prey in animal nests by hitch-hiking in the fur or feathers of the parent animal.



15–25 cm
6–10 in

IMPERIAL SCORPION
Pandinus imperator
F: Scorpionidae

One of the largest of all scorpions, this African forest species is more docile and has a milder sting than many of the desert-dwellers.

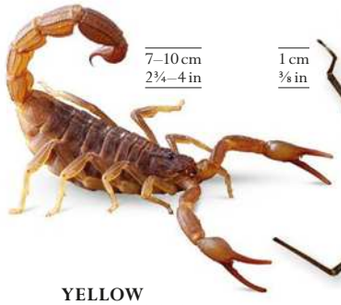
10–18 cm
4–7 in

AFRICAN ROCK SCORPION
Hadogenes phyllodes
F: Hemiscorpiidae

Typical of a family of rock scorpions, this southern African species has a broad, flat body for squeezing into cracks between rocks.

COMMON EUROPEAN SCORPION
Buthus occitanus
F: Buthidae

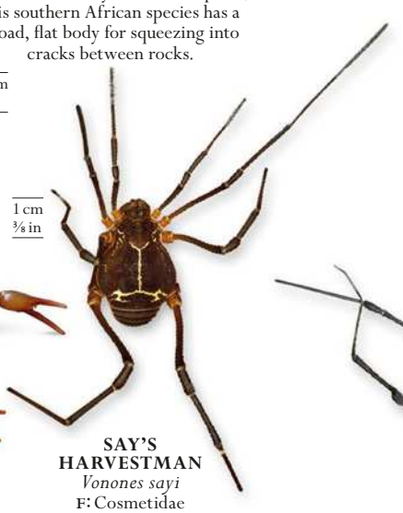
Found throughout N. Africa and around the Mediterranean, the toxicity of this species varies across its range, being most potent in the south.



7–10 cm
2¾–4 in

YELLOW FAT-TAIL SCORPION
Androctonus amoreuxi
F: Buthidae

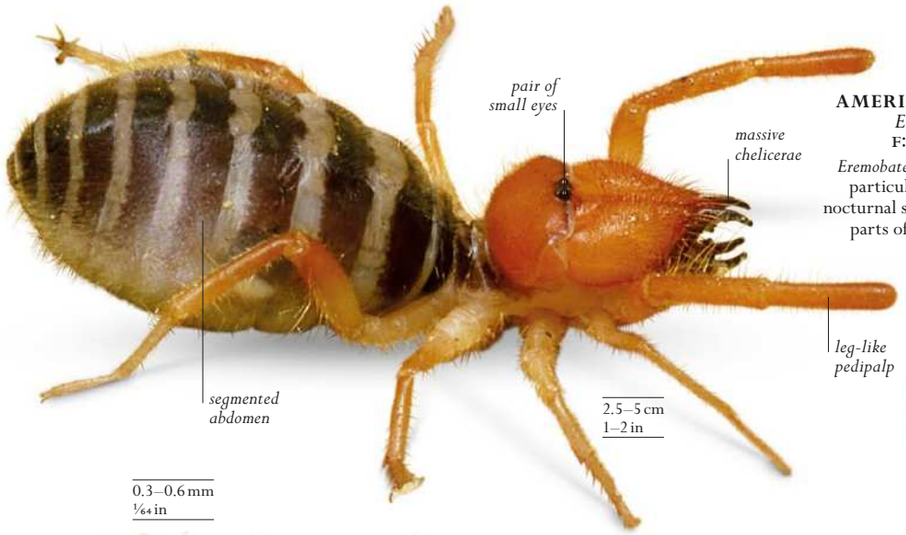
Most fat-tail scorpions are small but have potent venoms. This large species from the Sahara and Middle East has caused human fatalities.



1 cm
⅜ in

SAY'S HARVESTMAN
Vonones sayi
F: Cosmetidae

Harvestmen have an undivided body and are non-venomous. Many, including this American species, produce distasteful chemicals to deter predators.



AMERICAN SUN SPIDER
Eremobates sp.
F: Eremobatidae

Eremobates are sun spiders with particularly large jaws. This nocturnal species is found in warm parts of N. and C. America.

PAINTED SUN SPIDER
Metasolpuga picta
F: Solpugidae

Sun spiders, also called camel spiders, are fast-running, desert-living relatives of true spiders. This is a diurnal species from Namibia.

WIND SPIDER
Galeodes arabs
F: Galeodidae

A common species in the largest genus of sun spiders, this Middle Eastern species is named for its ability to tolerate sand storms.

FLOUR MITE
Acarus siro
F: Acaridae

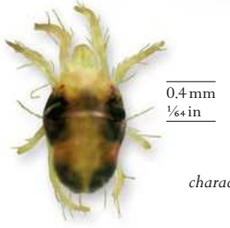
This is an important pest that feeds on stored cereal products. Like many other species, its presence can cause allergic reactions in humans.

AUTUMN CHIGGER
Neotrombicula autumnalis
F: Trombiculidae

Adults of chigger mites are vegetarian, but their larvae feed on the skin of other animals, including humans. Their chewing causes intense irritation.

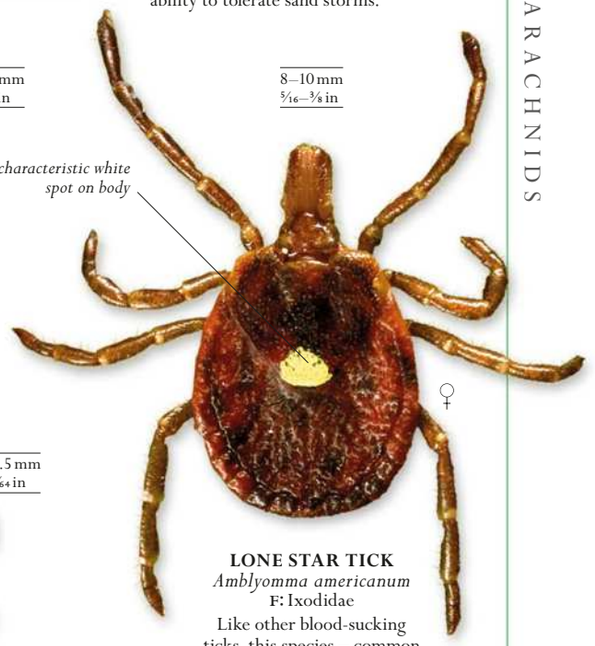
COMMON VELVET MITE
Trombidium holosericeum
F: Trombidiidae

This is a widespread Eurasian species of velvet mite. When young, it lives parasitically off other arthropods, but becomes predatory when mature.



RED SPIDER MITE
Tetranychus urticae
F: Tetranychidae

Spider mites are a family of mites that suck the sap of plants. They weaken the plant and can transmit viral diseases.



LONE STAR TICK
Amblyomma americanum
F: Ixodidae

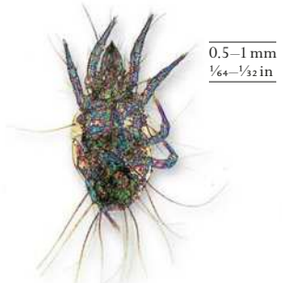
Like other blood-sucking ticks, this species – common in woodlands in the USA – can transmit a number of disease-causing microbes.

VARROA MITE
Varroa sp.
F: Varroidae

Parasitic on honeybees, young of this mite feed on bee larvae. When mature, they attach to and feed on adult bees and spread to other hives.

MANGE MITE
Sarcoptes scabiei
F: Sarcoptidae

This tiny mite burrows into the skin of various mammal species, completing its life cycle there. It causes scabies in humans and mange in carnivores.

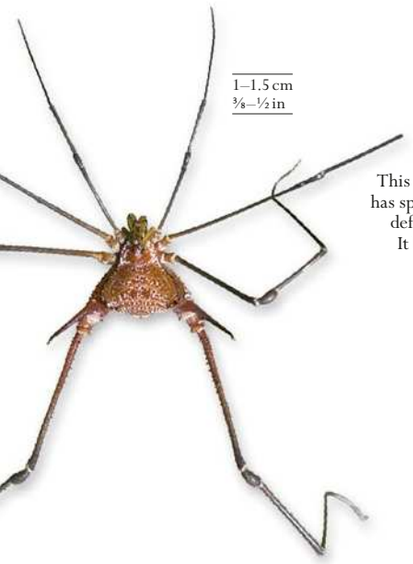


CHICKEN MITE
Dermanyssus gallinae
F: Dermanyssidae

A blood-sucking parasite of poultry, this mite lives – and completes its life cycle – in crevices away from its host, but emerges at night to feed.

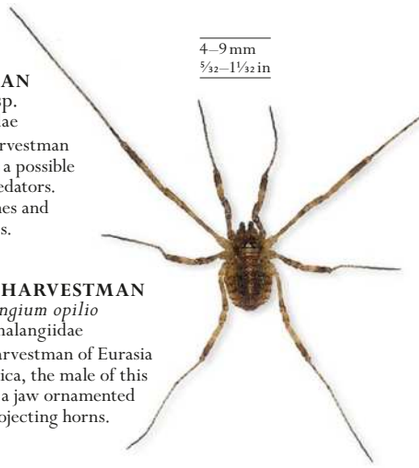
PERSIAN FOWL TICK
Argas persicus
F: Argasidae

A blood-sucking parasite of fowl, including domestic chickens, this oval-shaped, soft-bodied tick can spread disease between birds and can cause paralysis.



SPINY HARVESTMAN
Discocyrtus sp.
F: Gonyleptidae

This S. American harvestman has spiny hind legs as a possible defence against predators. It lives under stones and logs in forests.



HORNED HARVESTMAN
Phalangium opilio
F: Phalangiidae

A common harvestman of Eurasia and N. America, the male of this species has a jaw ornamented with projecting horns.

TAILLESS WHIP SPIDER
Phrynus sp.
F: Phrynidae

Whip spiders are not true spiders. They have long, whip-like front legs and pincers for grabbing prey, but lack venom. All are tropical.

WHIP SCORPION
Thelyphonus sp.
F: Thelyphonidae

Tropical whip scorpions such as this species have a whip-like tail, but no sting or venom. However, they can spray acetic acid from their abdomen.

»

» ARACHNIDS

FUNNEL-WEB SPIDER
Atrax robustus
F: Atracidae

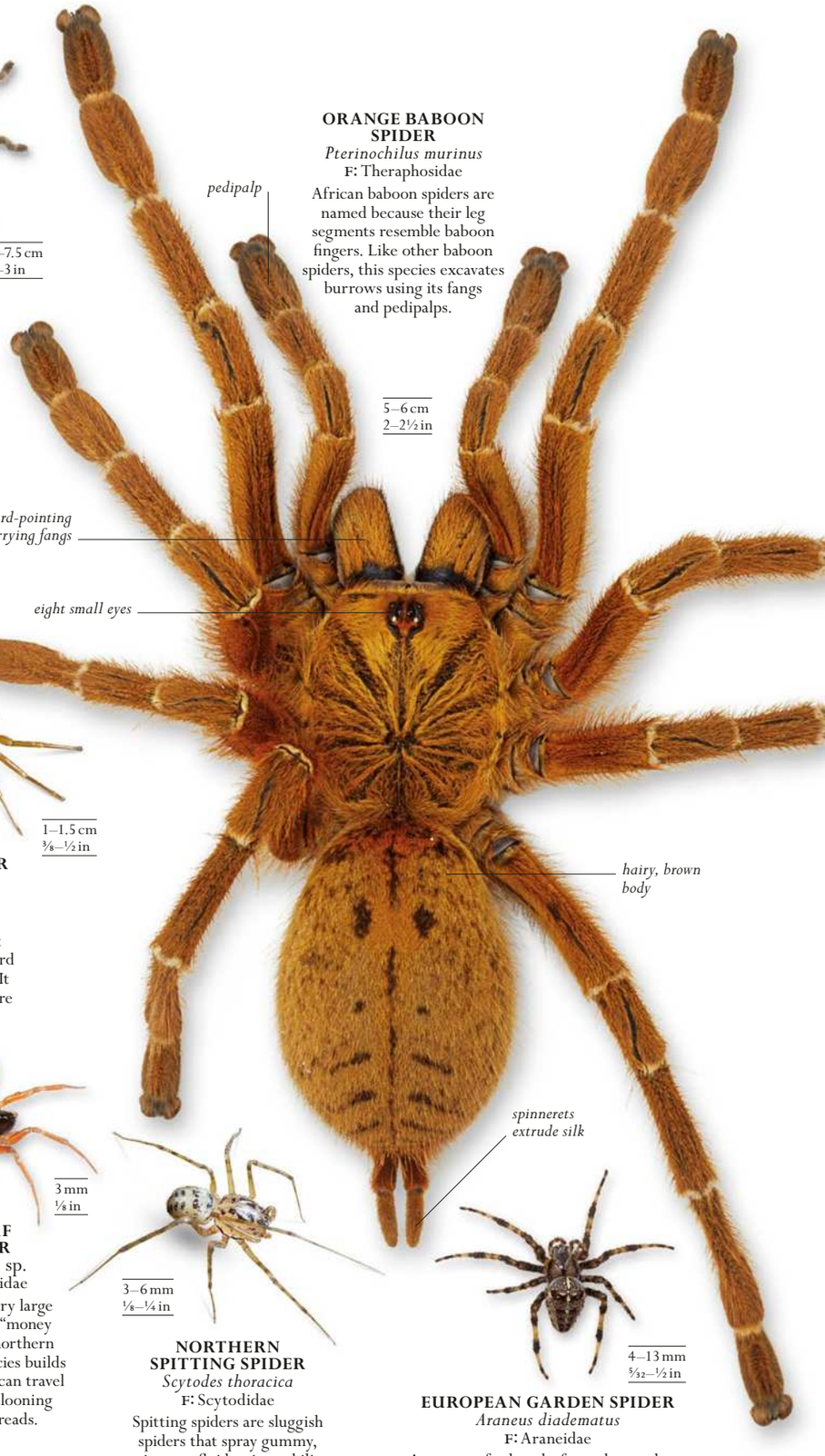
Females of this aggressive Australian spider live in burrows with funnel-like, silk-lined entrances. The dangerous bite most frequently comes from males wandering for mates.

MEXICAN RED-KNEED TARANTULA
Brachypelma smithi
F: Theraphosidae

This is one of many theraphosids: large-bodied spiders popularly called bird-eaters or tarantulas. They prey on large insects, rarely on small vertebrates.

CHACO TARANTULA
Acanthoscurria insubtilis
F: Theraphosidae

Many large theraphosids, such as this S. American species, live in disused rodent burrows. They are ambush predators, lying in wait for prey.



ORANGE BABOON SPIDER
Pterinochilus murinus
F: Theraphosidae

African baboon spiders are named because their leg segments resemble baboon fingers. Like other baboon spiders, this species excavates burrows using its fangs and pedipalps.

NORTH AMERICAN TRAPDOOR SPIDER
Ummidia audouini
F: Halonoproctidae

This N. American spider builds a cork-like trapdoor set with trip-lines. Stumbling prey alert the predator waiting in a silk-lined burrow beneath.

SIX-EYED SPIDER
Oonops domesticus
F: Oonopidae

This tiny, pink, six-eyed spider occurs in warm parts of Eurasia, but further north – including in Britain – it is found only in houses.

WOODLOUSE SPIDER
Dysdera crocata
F: Dysderidae

This nocturnal European spider has huge fangs that catch and break into the hard exoskeletons of woodlice. It occurs in damp places where woodlice are abundant.

LADYBIRD SPIDER
Eresus kollari
F: Eresidae

Only males of this Eurasian spider have the eponymous ladybird pattern. This species catches prey from within silk-lined burrows on heathland slopes.

DWARF SPIDER
Gonatium sp.
F: Linyphiidae

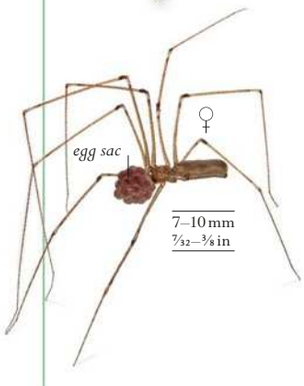
Typical of a very large family of tiny "money spiders", this northern hemisphere species builds sheet webs and can travel in wind by ballooning on silken threads.

NORTHERN SPITTING SPIDER
Scytodes thoracica
F: Scytodidae

Spitting spiders are sluggish spiders that spray gummy, poisonous fluid to immobilize prey before biting. This species spans the northern hemisphere.

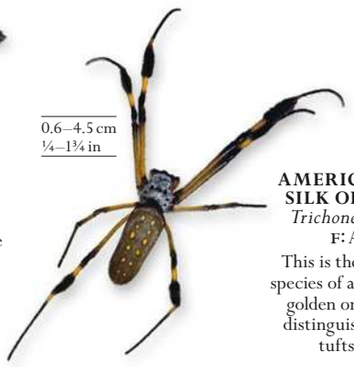
EUROPEAN GARDEN SPIDER
Araneus diadematus
F: Araneidae

A weaver of orb webs from the northern hemisphere, this spider of woodland, heath, and gardens is marked by a white cross on a variable background colour.



DADDY LONG-LEGS SPIDER
Pholcus phalangioides
F: Pholcidae

Spindly-legged pholcids vibrate their webs when disturbed. Many are cave dwellers, but this cosmopolitan species inhabits houses. Females carry eggs in their jaws.



AMERICAN GOLDEN SILK ORB-WEAVER
Trichonephila clavipes
F: Araneidae

This is the only American species of a group of tropical golden orb-weavers. It is distinguished by feathery tufts on its legs.

CRAB-LIKE SPINY ORB-WEAVER
Gasteracantha cancriformis
F: Araneidae

One of many American orb-weavers with defensive spines, this species inhabits the S. USA and the Caribbean. Colours of the body and spines vary.

4–13 mm
5/32–1/2 in

BLACK WIDOW SPIDER
Latrodectus mactans
F: Theridiidae

A small spider with venom unusually dangerous to humans, females of this N. American species frequently eat the smaller male after mating.

2–3 cm
3/4–1 1/4 in

TARANTULA WOLF SPIDER
Lycosa tarantula
F: Lycosidae

This species is the only true tarantula: a large member of the wolf spider family from Mediterranean Europe, not to be confused with hairy-bodied "bird-eaters".

5–8 mm
3/16–5/16 in

EUROPEAN WOLF SPIDER
Pardosa amentata
F: Lycosidae

A typical wolf spider, this furry brown spider hunts over ground without a web. Females carry an egg sac and young ride on the mother's back.

NURSERY WEB SPIDER
Pisaura mirabilis
F: Pisauridae

Females of this Eurasian spider carry their egg sac beneath the body by their jaws, before weaving a nursery "tent" of silk to protect hatching young.

1–1.5 cm
3/8–1/2 in

1.2 cm
3/8 in

CAVE SPIDER
Meta menardi
F: Tetragnathidae

Many spiders of the genus *Meta*, such as this European species, inhabit caves, where they suspend their drop-shaped egg sacs.

7–18 mm
7/32–7/10 in

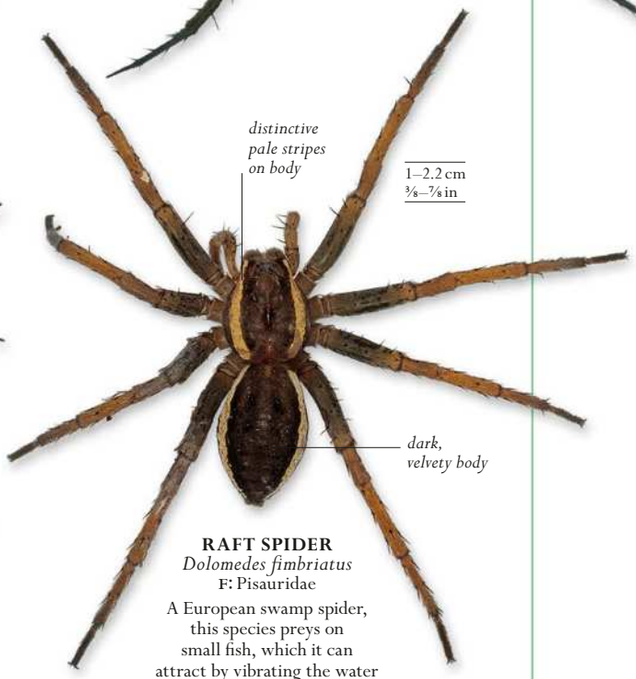
WATER SPIDER
Argyroneta aquatica
F: Dictynidae

The only routinely aquatic spider, this Eurasian pond species builds a submerged, air-filled chamber, inside which it eats its prey, including small fish.

1–1.8 cm
3/8–3/4 in

GIANT HOUSE SPIDER
Eratigena duellica
F: Agelenidae

A member of a group of spiders that build sheet webs with tubular retreats, this species frequents buildings across the northern hemisphere.



1–2.2 cm
3/8–7/8 in

RAFT SPIDER
Dolomedes fimbriatus
F: Pisauridae

A European swamp spider, this species preys on small fish, which it can attract by vibrating the water surface with its legs.

3–5 cm
1 1/4–2 in

BRAZILIAN WANDERING SPIDER
Phoneutria nigriventer
F: Ctenidae

Wandering spiders get their name from their nocturnal roaming habits. This species from Brazilian forests is believed to be the world's most venomous spider.

5–10 mm
3/16–3/8 in

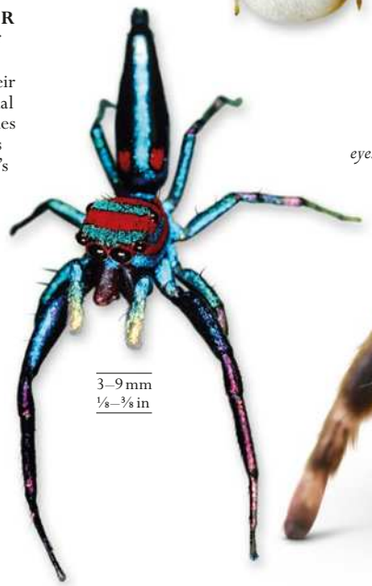
CRAB SPIDER
Misumena vatia
F: Thomisidae

Females of this northern hemisphere spider can slowly change their colour from white to yellow for camouflage in flowers before ambushing nectar-feeding insects.

2–3 cm
3/4–1 1/4 in

BROWN HUNTSMAN SPIDER
Heteropoda venatoria
F: Sparassidae

Widespread throughout tropical and subtropical regions, this large but harmless spider is sometimes welcomed in homes for preying on cockroaches.



3–9 mm
1/8–3/8 in

ELEGANT JUMPING SPIDER
Chrysilla lauta
F: Salticidae

Jumping spiders are especially diverse in the tropics. Many, such as this E. Asian species, are strikingly coloured, sometimes to aid communication.

5–7 mm
3/16–7/32 in

BROWN JUMPING SPIDER
Evarcha arcuata
F: Salticidae

This Eurasian grassland species is one of thousands of species of jumping spiders with acute binocular vision and complex courtship behaviour.

MEXICAN RED-KNEED TARANTULA

Brachypelma smithi

SIZE Body length 5–7.5 cm (2–3 in)
HABITAT Tropical deciduous forests
DISTRIBUTION Mexico
DIET Mostly insects

With its stout, furry body, the Mexican red-kneed tarantula might seem more mammal-like than spider-like. The female can live up to 30 years, which is unusual for an invertebrate, but the life span of the male is only up to six years. *Brachypelma smithi* is one of a group of spiders that gets the nickname of bird-eater because of their size, and although most of their diet consists of fellow arthropods, they can and do take down small mammals and reptiles when the opportunity arises. In its native Mexico this species lives in burrows in earth banks, where it is safe to moult and lay eggs, and from which it ambushes its prey. Habitat destruction is now a threat, and, as the species makes a popular pet, it is routinely bred in captivity.

< EYES
Like most spiders, the tarantula has eight simple eyes arranged at the front of the head. Even so, it has poor vision, and relies more on touch than sight to sense its surroundings and the presence of prey.

< JOINTS
Like all arthropods, tarantulas have jointed legs. Each leg consists of seven tubular sections of exoskeleton that connect via flexible joints. Muscles run through these joints to move the sections.

^ VENOMOUS FANGS
Tarantula fangs hinge forward when attacking prey – unlike most other spiders, whose fangs are angled towards each other. Both fangs inject venom from muscular sacs within the head to paralyse the victim.

< FOOT
At the tip of each foot are two claws used for grip as the tarantula moves. As in other hunting spiders, there are also pads of tiny hairs for extra purchase on smooth surfaces.

< SPINNERETS
Glands in the abdomen produce silk in liquid form. Using its hind legs, the tarantula pulls the silk from tubes called spinnerets. The silk solidifies into threads used to make egg sacs and line the spider's burrow.

dark abdomen contains most of the animal's vital internal organs
orange-red patella, or knee
palps are used for feeling, groping prey, and transferring sperm to the female

^ HAIRY WEAPONS
Like many tropical American tarantulas, this spider defends itself by rubbing its hind legs against its abdomen to release the barbed, stinging hairs that grow there. These urticating hairs are tiny and light, and designed to float in a cloud around a predator's face, getting in its eyes, nose, and mouth. They cause intense irritation when lodged in skin.

UNDERSIDE >
The head and thorax are fused into one body part, which carries the legs and mouthparts. The abdomen has openings for breathing and reproduction, and two pairs of spinnerets at the rear.

SEA SPIDERS

These fragile-looking marine animals live among seaweeds in shallow seas and coral reefs in tropical waters. The largest species live in the deep ocean.

Sea spiders of the class Pycnogonida are not true spiders, and are so remarkably different from other arthropods that some scientists think they belong to an ancient lineage that is not closely related to any groups alive today. Others think they are distant cousins of the arachnids. Most sea spiders are small – less than a centimetre (⅜in) in body length. They have three or four pairs of legs and the head and thorax are fused together. Instead of claw-like mouthparts they have a stabbing proboscis, which they use like a hypodermic needle to suck fluids from their invertebrate prey. Their spindly body shape means they do not need gills; they rely instead on oxygen seeping directly into all their cells through their body surface.

PHYLUM	ARTHROPODA
CLASS	PYCNOGONIDA
ORDER	1
FAMILIES	13
SPECIES	1,348

2 cm
¾ in

GIANT SEA SPIDER
Colossendeis megalonyx
F: Colossendeidae
One of the largest of all sea spiders, this is a deep-sea animal of sub-Antarctic waters, with a leg span of 70 cm (28 in).

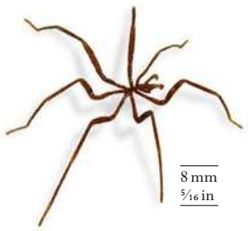
8 mm
5/16 in

SPINY SEA SPIDER
Endeis spinosa
F: Endeidae
This sea spider – found around European coasts but perhaps ranging elsewhere – has an especially spindly body, with a long cylindrical proboscis.

5 mm
3/16 in

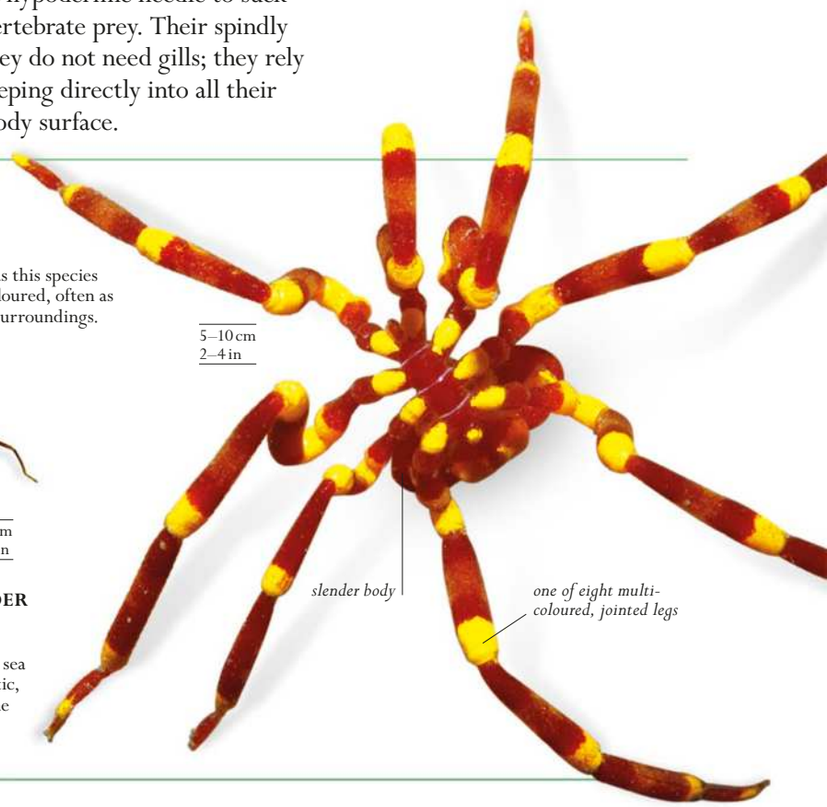
FAT SEA SPIDER
Pycnogonum litorale
F: Pycnogonidae
Unlike most other sea spiders, this European species has a thick body and comparatively short, curved, clawed legs. It feeds on anemones.

YELLOW-KNEED SEA SPIDER
Unknown sp.
F: Callipallenidae
Some species of sea spiders – such as this species of Australian reefs – are strikingly coloured, often as camouflage against their colourful surroundings.



8 mm
5/16 in

GRACEFUL SEA SPIDER
Nymphon brevirostre
F: Nymphonidae
One of the most common sea spiders of the N.E. Atlantic, this species occurs in the intertidal zone and in offshore shallows.

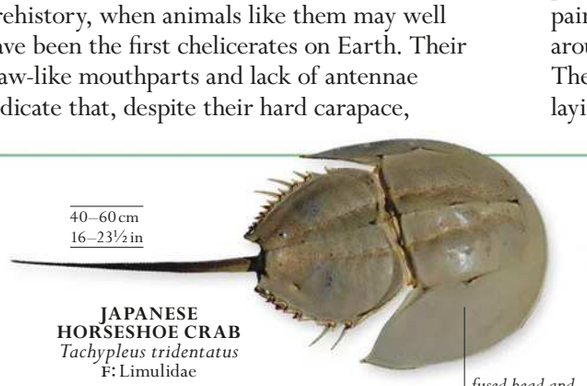


HORSESHOE CRABS

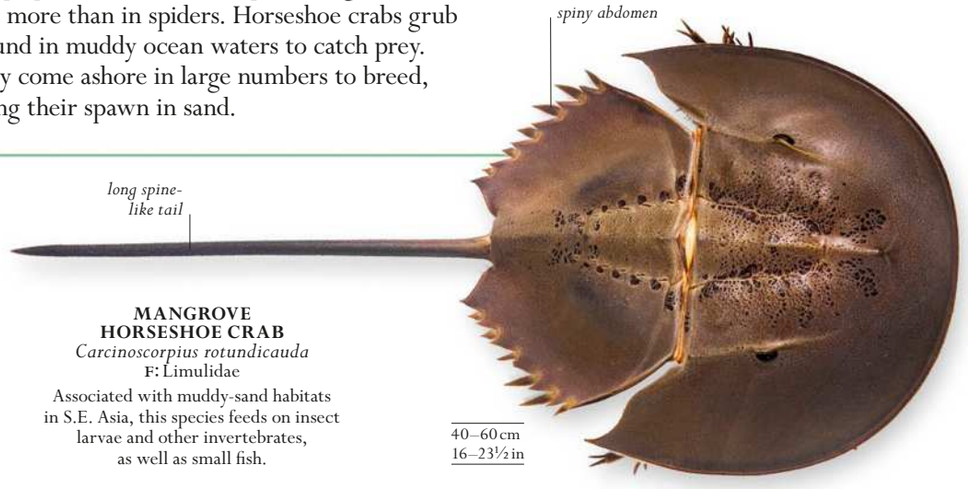
The Merostomata are a small class of sea-dwelling relatives of spiders and scorpions. Of prehistoric origin, they are widely regarded as "living fossils".

Horseshoe crabs were far more diverse in prehistory, when animals like them may well have been the first chelicerates on Earth. Their claw-like mouthparts and lack of antennae indicate that, despite their hard carapace, horseshoe crabs are most closely related to arachnids. The leaf-like gills on the underside of their abdomens are the forerunners of similar internal structures – the so-called book lungs – that arachnids use to breathe on land. The pedipalps are used as a fifth pair of legs, one pair more than in spiders. Horseshoe crabs grub around in muddy ocean waters to catch prey. They come ashore in large numbers to breed, laying their spawn in sand.

PHYLUM	ARTHROPODA
CLASS	MEROSTOMATA
ORDER	1
FAMILY	1
SPECIES	4



JAPANESE HORSESHOE CRAB
Tachypleus tridentatus
F: Limulidae
This horseshoe crab spawns in sandy shores of E. Asia. Habitat destruction and pollution have depleted its numbers in some parts of its range.



MANGROVE HORSESHOE CRAB
Carcinoscorpius rotundicauda
F: Limulidae
Associated with muddy-sand habitats in S.E. Asia, this species feeds on insect larvae and other invertebrates, as well as small fish.

CRUSTACEANS

Most crustaceans are aquatic, breathe with gills, and have limbs for crawling or swimming. A few are sedentary as adults, parasitic, or land living.

The basic body plan of a crustacean consists of a head, thorax, and abdomen, though in many groups the head and thorax are fused together. In crabs, lobsters, and prawns a frontal flap grows backwards to cover the entire head and thorax with a shell-like carapace. Crustaceans are the only arthropods that have two pairs of antennae and primitively two-pronged limbs. Limbs on the thorax are usually used for locomotion, but in some species they are modified as pincers for feeding or defence. Many crustaceans also have well-developed abdominal limbs, which are often used for brooding young. Gills tie most crustaceans to water, although woodlice and some crabs have modified breathing organs that enable them to live in damp places on land.

Being permanently under water, where their weight is supported, means that crustaceans can develop a thick, heavy exoskeleton. Many species have an exoskeleton hardened with minerals, which are reabsorbed between moults when the outer coating of the body is shed. With their body buoyed up by water, many crustaceans have become bigger than their land-based relatives. The world's largest arthropod is the deep-sea Japanese spider crab (leg span 4m/13ft). At the other extreme, crustaceans make up the bulk of animal life in plankton, either as tiny larvae or as adult shrimps and krill.

PHYLUM	ARTHROPODA
SUBPHYLUM	CRUSTACEA
ORDERS	56
FAMILIES	About 1,000
SPECIES	About 70,000

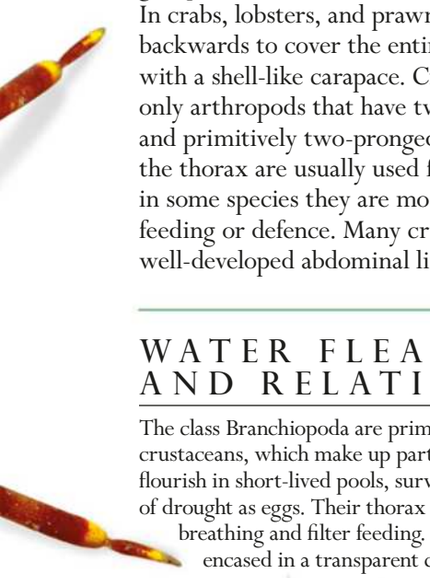
DEBATE

CRUSTACEAN ANCESTRY

Crustaceans have many unique features, including double antennae and two-pronged limbs, that suggest they are exclusive descendants of a single common ancestor. However, recent DNA analysis shows that insects are also descended from the crustacean group.

WATER FLEAS AND RELATIVES

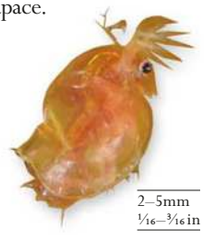
The class Branchiopoda are primarily freshwater crustaceans, which make up part of the plankton that flourish in short-lived pools, surviving long periods of drought as eggs. Their thorax carries leafy limbs for breathing and filter feeding. Water fleas are typically encased in a transparent carapace.



1–1.5 cm
⅜–½ in

BRINE SHRIMP
Artemia salina
F: Artemiidae

This soft-bodied, stalk-eyed animal is found worldwide in salt pools and swims upside down. Its hard-shelled eggs can resist years of drought.



2–5mm
1/16–3/16 in

LARGE WATER FLEA
Daphnia magna
F: Daphniidae

This N. American water flea, like its relatives, can brood eggs inside its carapace. These hatch without fertilization, rapidly populating ponds as a result.

1.5mm
1/16 in

MARINE WATER FLEA
Evadne nordmanni
F: Podonidae

Most water fleas – named for their jerky swimming – occur in stagnant freshwater pools. This, however, is a saltwater species of oceanic plankton.

VERNAL POOL TADPOLE SHRIMP
Lepidurus packardi
F: Triopsidae

Tadpole shrimps are ancient, bottom-living crustaceans of temporary freshwater pools. Relatives of this Californian species have changed little in 220 million years of evolution.

BARNACLES AND COPEPODS

Like other marine crustaceans, the class Maxillopoda start life as tiny planktonic larvae. Barnacle larvae cement themselves, head down, on rocks. Most copepods stay free-swimming, although some become parasites.

0.5–1.5 cm
3/16–½ in

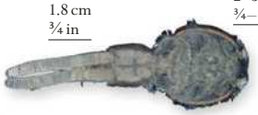
COMMON ACORN BARNACLE
Semibalanus balanoides
F: Archaeobalanidae

Sensitive to drying out, this intertidal species is most abundant at the base of the barnacle zone on exposed North Atlantic rocky coastlines.

5–10 cm
2–4 in

GIANT ACORN BARNACLE
Balanus nubilus
F: Balanidae

The world's largest barnacle, this species occurs attached to rocks below the intertidal level along the Pacific N. American coast.



1.8 cm
¾ in

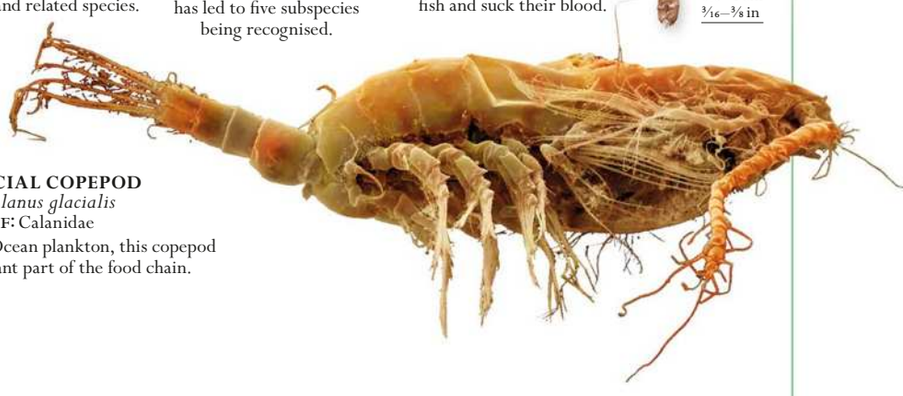
SEA LOUSE
Caligus sp.
F: Caligidae

A representative of a group of copepods that are parasitic on marine fish, this crustacean attacks salmon and related species.

2–3 cm
¾–1¼ in

ASIAN ACORN BARNACLE
Tetraclita squamosa
F: Tetraclitidae

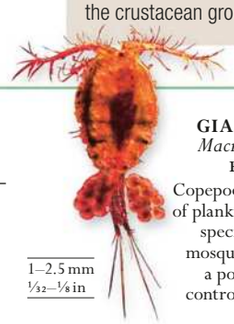
This acorn barnacle lives in the intertidal zone on Indo-Pacific shores. Recent research has led to five subspecies being recognised.



3–5 mm
1/8–3/16 in

GLACIAL COPEPOD
Calanus glacialis
F: Calanidae

Within Arctic Ocean plankton, this copepod is an important part of the food chain.



1–2.5 mm
1/32–1/8 in

GIANT COPEPOD
Macrocyclops albidus
F: Cyclopidae

Copepods are tiny predators of plankton; this widespread species even preys on mosquito larvae, offering a potential means of controlling these insects.

DEEP SEA GOOSE BARNACLE
Neolepas sp.
F: Eolepadidae

This goose barnacle ally lives around volcanic vents on the ocean floor, where it filter-feeds on other organisms including bacteria.

5–10 cm/2–4 in

COMMON GOOSE BARNACLE
Lepas anatifera
F: Lepadidae

Goose barnacles are attached – mostly to oceanic flotsam – by a flexible stalk. This species occurs in temperate waters of the N.E. Atlantic.

8–90 cm
3¼–36 in

COMMON FISH LOUSE
Argulus sp.
F: Argulidae

This is a flattened, fast-swimming crustacean with an oval carapace. It uses suckers to attach to fish and suck their blood.

0.5–1 cm
3/16–⅜ in

SEED SHRIMPS

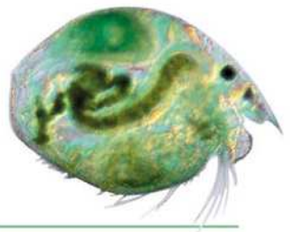
Seed shrimps belong to the class Ostracoda. The entire body of a seed shrimp is enclosed within a two-valve hinged carapace, with just the limbs poking through. If threatened, the animal can shut itself inside. These small crustaceans crawl through vegetation in marine and freshwater habitats; some use their antennae to swim.

2–3 cm
¾–1¼ in

GIANT SWIMMING SEED SHRIMP
Gigantocypris sp.
F: Cypridinidae

Most seed shrimps are tiny crustaceans with two-valved carapaces; this is a large, deep-sea species with big eyes for hunting bioluminescent prey.

0.5–2 mm
1/64–1/16 in



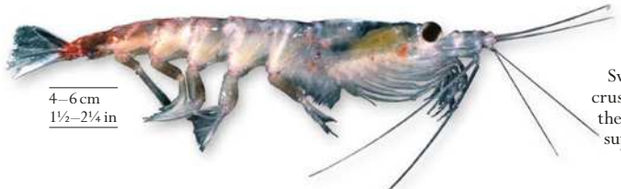
CRAWLING SEED SHRIMP
Cypris sp.
F: Cyprididae

This widespread freshwater crustacean belongs to a group of small, hard-shelled seed shrimps that crawl through detritus.

CRABS AND RELATIVES

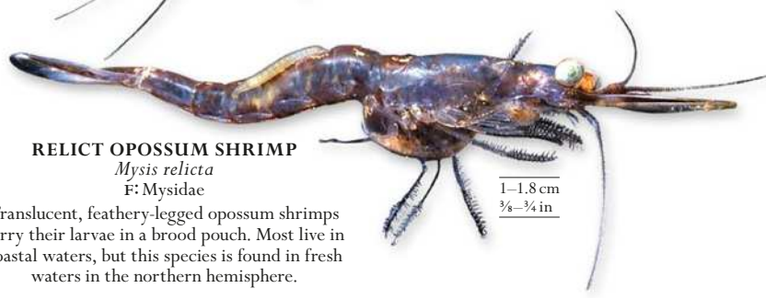
The Malacostraca class is the most diverse crustacean group. The basic features are head, thorax, and an abdomen with multiple limbs. Two large orders within this class include the decapods, which have a carapace that curves round the fused head-thorax to contain a gill cavity, and the isopods (woodlice and relatives), which lack a carapace and are the largest group of land-living crustaceans.

4–6 cm
1½–2¼ in



ANTARCTIC KRILL
Euphausia superba
F: Euphausiidae

Swarms of these plankton-feeding crustaceans are critical components of the Southern Ocean food chains that support whales, seals, and seabirds.



1–1.8 cm
⅜–¾ in

RELICT OPOSSUM SHRIMP
Mysis relicta
F: Mysidae

Translucent, feathery-legged opossum shrimps carry their larvae in a brood pouch. Most live in coastal waters, but this species is found in fresh waters in the northern hemisphere.

1.5–2.2 cm
½–⅞ in

COMMON SANDHOPPER
Orchestia gammarellus
F: Talitridae

One of many amphipods (sideways-flattened crustaceans), this is a European intertidal sandhopper – so called because it can jump by flipping its abdomen.

1–2 cm
⅜–¾ in

COMMON FRESHWATER SHRIMP
Gammarus pulex
F: Gammaridae

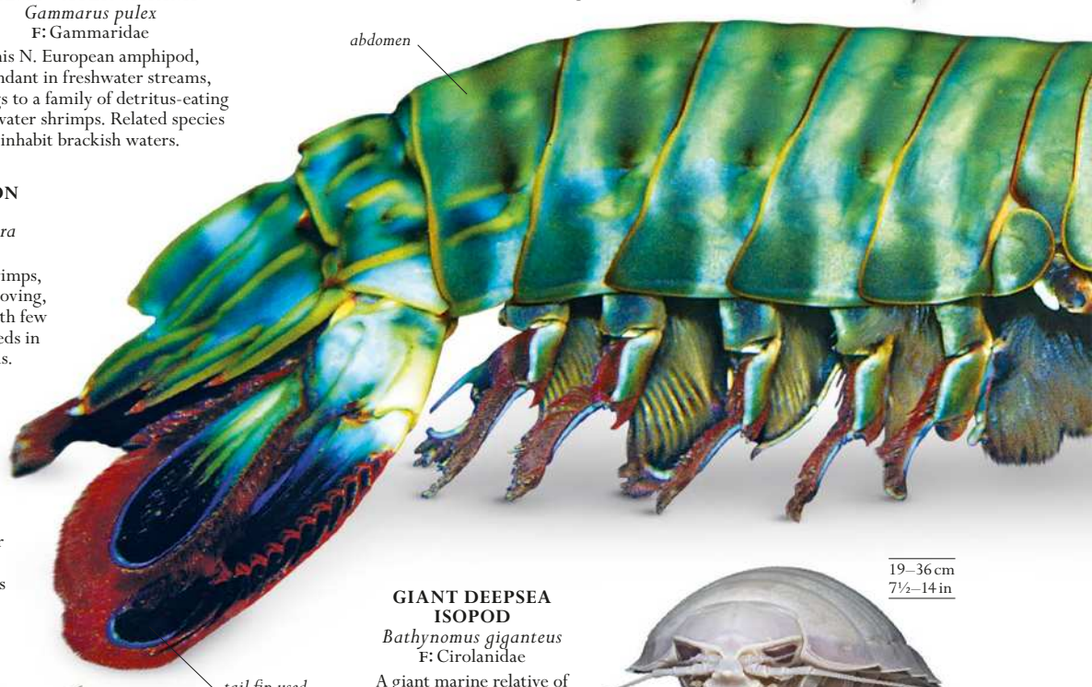
This N. European amphipod, abundant in freshwater streams, belongs to a family of detritus-eating freshwater shrimps. Related species inhabit brackish waters.

13 mm
½ in

SPINY SKELETON SHRIMP
Caprella acanthifera
F: Caprellidae

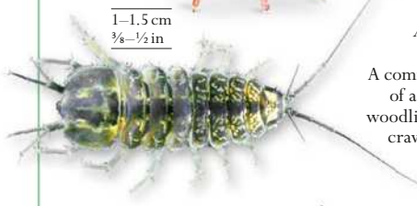
Like other skeleton shrimps, this is a slender, slow-moving, predatory amphipod with few legs. It clings to seaweeds in European rockpools.

abdomen



tail fin used for swimming

1–1.5 cm
⅜–½ in



COMMON WATER SLATER
Asellus aquaticus
F: Asellidae

A common European member of a family of freshwater woodlice relatives, this species crawls among detritus in stagnant water.

19–36 cm
7½–14 in

GIANT DEEPSEA ISOPOD
Bathynomus giganteus
F: Cirolanidae

A giant marine relative of woodlice, this species crawls along ocean floors, scavenging on dead animals and occasionally taking live prey.

2–3 cm
¾–1¼ in

COMMON SEA SLATER
Ligia oceanica
F: Ligiidae

A large coastal woodlouse, this European species lives in rock crevices above the intertidal zone. It feeds on detritus.

10–12 cm
4–4¾ in

BLACK-HEADED WOODLOUSE
Porcellio spinicornis
F: Porcellionidae

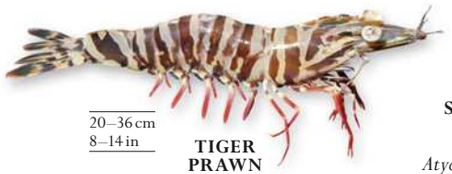
Often living alongside humans, especially in lime-rich habitats, this distinctly marked woodlouse is native to Europe but has invaded N. America.

segmented exoskeleton

1–1.8 cm
⅜–¾ in

COMMON PILL WOODLOUSE
Armadillidium vulgare
F: Armadillidiidae

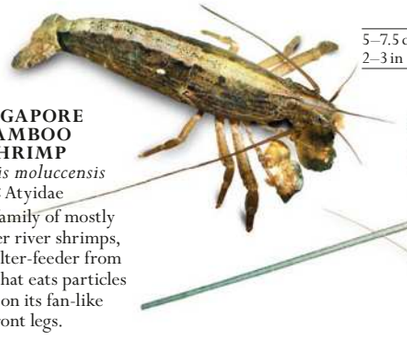
Pill woodlice are characterized by their ability to roll into a ball when disturbed. This species is widespread across Eurasia and introduced elsewhere.



20–36 cm
8–14 in

TIGER PRAWN
Penaeus monodon
F: Penaeidae

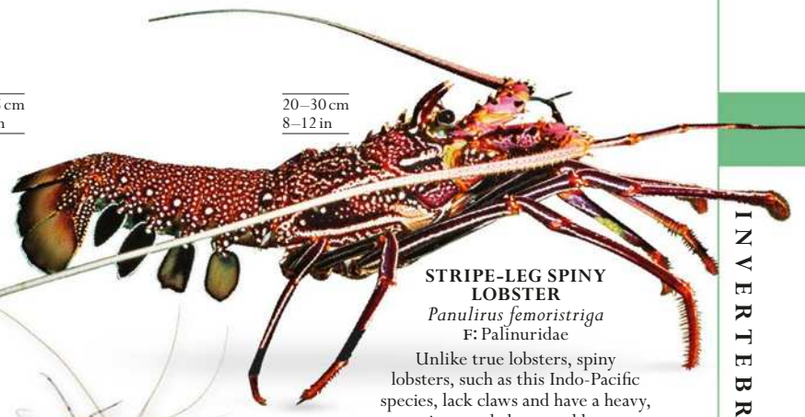
This widely farmed, giant Indo-Pacific prawn belongs to a group that does not brood its fertilized eggs, but releases them directly into the sea.



5–7.5 cm
2–3 in

SINGAPORE BAMBOO SHRIMP
Atyopsis moluccensis
F: Atyidae

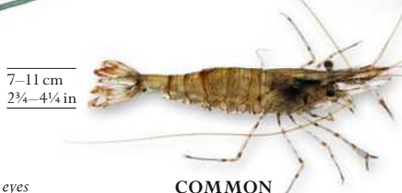
From a family of mostly freshwater river shrimps, this is a filter-feeder from S.E. Asia that eats particles caught on its fan-like front legs.



20–30 cm
8–12 in

STRIPE-LEG SPINY LOBSTER
Panulirus femoristriga
F: Palinuridae

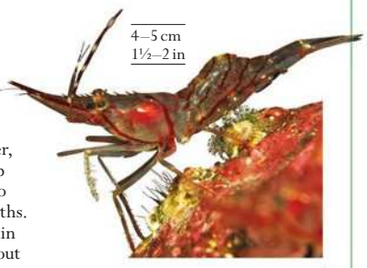
Unlike true lobsters, spiny lobsters, such as this Indo-Pacific species, lack claws and have a heavy, spiny exoskeleton and long, stout antennae.



7–11 cm
2¾–4¼ in

COMMON PRAWN
Palaemon serratus
F: Palaemonidae

A large, commercially important member of a family of shrimps with a jagged-edged carapace, this species inhabits northeast Atlantic coasts, frequenting the intertidal zone.



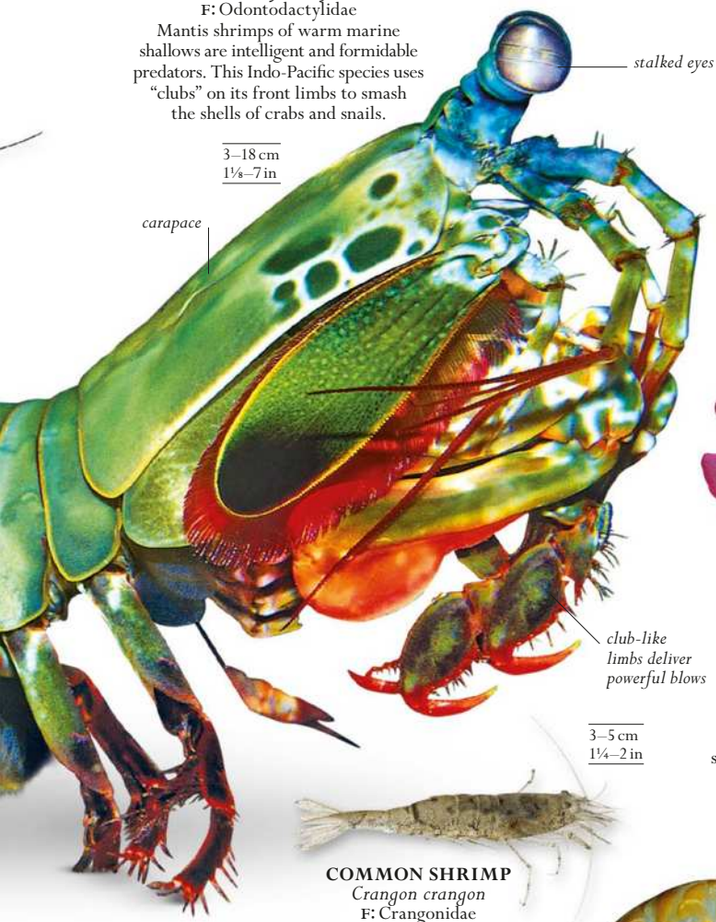
4–5 cm
1½–2 in

AESOP SHRIMP
Pandalus montagui
F: Pandalidae

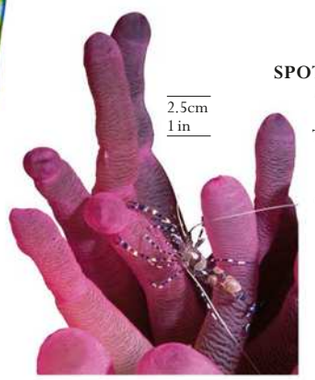
Males of this cold-water, North Atlantic shrimp sometimes change into females after 13–16 months. Other individuals remain male or female throughout their lives.

PEACOCK MANTIS SHRIMP
Odontodactylus scyllarus
F: Odontodactylidae

Mantis shrimps of warm marine shallows are intelligent and formidable predators. This Indo-Pacific species uses "clubs" on its front limbs to smash the shells of crabs and snails.



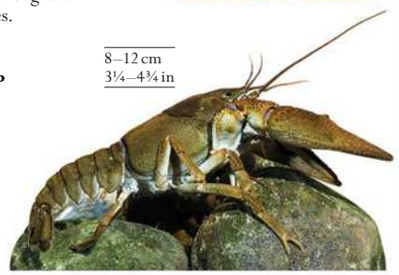
3–18 cm
1⅛–7 in



2.5 cm
1 in

SPOTTED CLEANER SHRIMP
Periclimenes yucatanicus
F: Palaemonidae

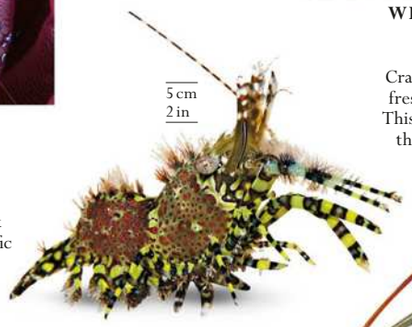
This Caribbean crustacean lives in sea anemones and – like many other reef-dwelling shrimps – cleans visiting fish of their dead skin and parasites.



8–12 cm
3¼–4¾ in

WHITE-CLAWED CRAYFISH
Austropotamobius pallipes
F: Astacidae

Crayfish are small, mostly nocturnal, freshwater relatives of true lobsters. This is a European stream species and the only crayfish native to Britain.



5 cm
2 in

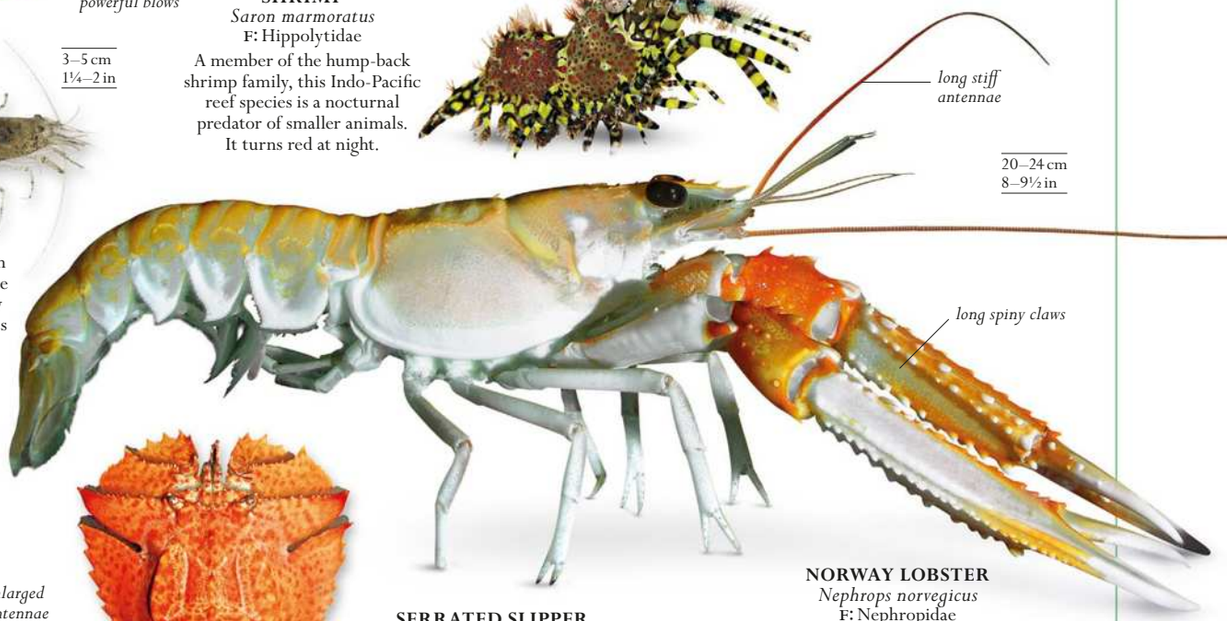
COMMON MARBLE SHRIMP
Saron marmoratus
F: Hippolytidae

A member of the hump-back shrimp family, this Indo-Pacific reef species is a nocturnal predator of smaller animals. It turns red at night.

3–5 cm
1¼–2 in

COMMON SHRIMP
Crangon crangon
F: Crangonidae

This shallow-water crustacean is commercially fished on some European coasts. It habitually hides in sand with only its eyes and antennae showing.

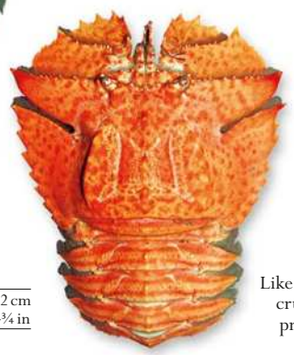


20–24 cm
8–9½ in

5–20 cm
2–8 in

SCULPTURED SLIPPER LOBSTER
Parribacus antarcticus
F: Scyllaridae

Relatives of spiny lobsters, clawless slipper lobsters have flattened, plate-like antennae. This nocturnal species lives on tropical reefs with sandy bottoms.



5–12 cm
2–4¾ in

SERRATED SLIPPER LOBSTER
Ibacus brevipes
F: Scyllaridae

Like other slipper lobsters, this Indo-Pacific crustacean can swim rapidly away from predators by flapping its broad tail fan.

NORWAY LOBSTER
Nephrops norvegicus
F: Nephropidae

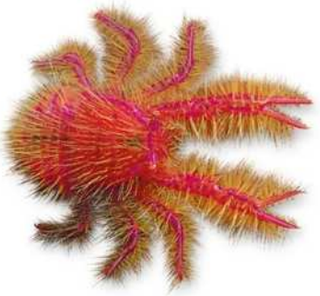
This North Atlantic crustacean tunnels in mud, often cohabiting with goby fish. It is a small-bodied true lobster, commercially marketed as langoustine or scampi.

»

» CRABS AND RELATIVES

ROBBER CRAB
Birgus latro
F: Coenobitidae

The largest land-living arthropod, this hermit crab is a relative of squat lobsters and inhabits Indo-Pacific island forests, eating coconuts using its massive pincers.



PINK SQUAT LOBSTER
Lauriea siagiani
F: Galatheidae

Many tropical squat lobsters are associated with specific reef organisms. This tiny, hairy Indonesian species lives on *Xestospongia* vase sponges.

BLUE-STRIPED SQUAT LOBSTER
Galathea strigosa
F: Galatheidae

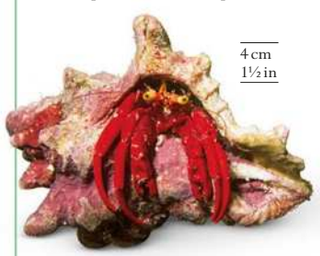
Slender-clawed squat lobsters such as this European species are decapods (ten-legged), but the last leg pair is reduced, making them appear eight-legged.

ANEMONE PORCELAIN CRAB
Neopetrolisthes maculatus
F: Porcellanidae

Porcelain crabs are tiny, eight-legged decapods more closely related to squat lobsters than true crabs. This Indo-Pacific species lives in giant *Stichodactyla* anemones.

INDO-PACIFIC PEA CRAB
Pinnotheres sp.
F: Pinnotheridae

Tiny pea crabs complete their life cycle on or in the body of other marine invertebrates. This Philippine species lives on cup corals.



RED REEF HERMIT CRAB
Paguristes cadenati
F: Diogenidae

Hermit crabs inhabit discarded snail shells that accommodate their soft coiled abdomen. This species lives on Indo-Pacific and E. Atlantic reefs.

WHITE-SPOTTED HERMIT CRAB
Dardanus megistos
F: Diogenidae

This crustacean of the E. Atlantic and Indo-Pacific coasts is a "left-handed" hermit crab, with an enlarged left claw.

ANEMONE HERMIT CRAB
Dardanus pedunculatus
F: Diogenidae

This hermit crab of Indo-Pacific reefs always carries a *Calliactis* anemone on its shell, which shares its food and provides camouflaged protection.

5–6.5 cm
2–2½ in

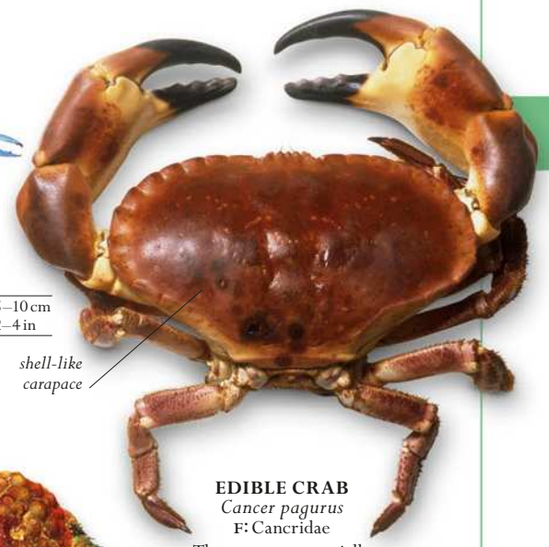
VELVET SWIMMING CRAB
Necora puber
F: Polybiidae

Swimming crabs have paddle-like rear legs. This aggressive, red-eyed species is common at low shore level on rocky coasts in the N.E. Atlantic.

5–7 cm
2–2¾ in

BLUE SWIMMING CRAB
Portunus pelagicus
F: Portunidae

This Indo-Pacific swimming crab favours sandy or muddy coastlines, with juveniles entering the intertidal zone. Like its relatives, it preys on other invertebrates.



5–10 cm
2–4 in

shell-like carapace

4–6 cm
1½–2¼ in

EDIBLE CRAB
Cancer pagurus
F: Cancridae

The most commercially important European crab, this offshore species has a distinctive wide "piecrust" carapace and can live for more than 20 years.

SPOTTED CORAL CRAB
Carpilius maculatus
F: Carpiliidae

One of several species of brightly coloured, coral-living crabs with many fossil relatives, this large species is found in the Indian and Pacific oceans.

4.5–9 cm
1¾–3½ in

WARTY BOX CRAB
Calappa hepatica
F: Calappidae

A tortoise-like crab, this Indo-Pacific, sand-burrowing species habitually shields its face with its claws, earning it the alternative name of shame-face crab.

4–5 cm
1½–2 in

SPONGE CRAB
Dromia personata
F: Dromiidae

This Atlantic crab often carries sponge pieces to hide itself from predators. Its reduced hind legs are like those of the related, primitive hermit crabs.

2–3 cm
¾–1¼ in

PAINTED PEBBLE CRAB
Leucosia anatum
F: Leucosiidae

Belonging to a family of small, mostly diamond-shaped crabs with long claws, this colourful species occurs in the Indian Ocean.

30–40 cm
12–16 in

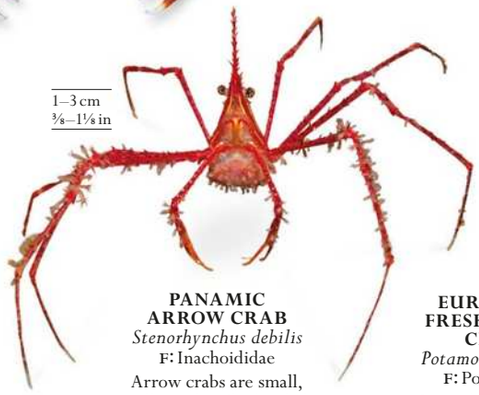
JAPANESE SPIDER CRAB
Macrocheira kaempferi
F: Inachidae

With legs spanning 4 m (13 ft), this is the world's biggest arthropod. It occurs in N.W. Pacific waters and reputedly lives for up to 100 years.

8–10 cm
3¼–4 in

CHRISTMAS ISLAND RED CRAB
Gecarcoidea natalis
F: Gecarcinidae

This land-living crab lives in burrows only in the forests of Christmas Island. Huge numbers march in an annual migration to the sea for spawning.



1–3 cm
⅜–1⅛ in

PANAMIC ARROW CRAB
Stenorhynchus debilis
F: Inachoididae

Arrow crabs are small, stalk-eyed, spiky-headed spider crabs. This E. Pacific species is a reef-dwelling scavenger.

4–5cm
1½–2in

EUROPEAN FRESHWATER CRAB
Potamon potamios
F: Potamidae

A member of a large family of Eurasian crabs from alkaline fresh waters, this southern European species spends much of its time on land.

eyes on stalks

1–2 cm
⅜–¾ in

ORANGE FIDDLER CRAB
Gelasimus vocans
F: Ocypodidae

Fiddler crabs are burrowing beach crabs with an enlarged signalling claw in males. This species lives on muddy W. Pacific shores.

5–6 cm
2–2¼ in

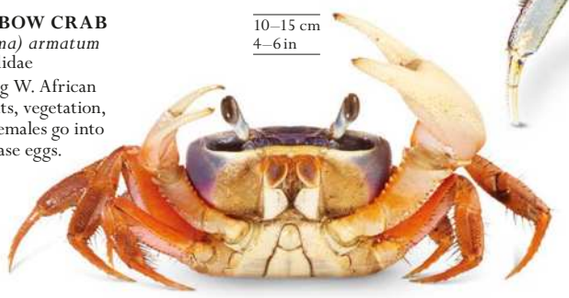
furry claws

CHINESE MITTEN CRAB
Eriocheir sinensis
F: Varunidae

Native to E. Asia, this furry-clawed, burrowing river crab was introduced to N. America and Europe, where it has become a pest.

AFRICAN RAINBOW CRAB
Ocypode (Cardisoma) armatum
F: Ocypodidae

This shore-dwelling W. African species feeds on fruits, vegetation, and animals. Only females go into the sea to release eggs.



10–15 cm
4–6 in

AFRICAN RAINBOW CRAB

Ocypode (Cardisoma) armatum

African rainbow crabs dig deep individual burrows above the shoreline on sandy beaches, dunes, mangrove swamps, and estuaries. They mate in or near the burrows and females then carry the fertilized eggs under their abdomen for 2–3 weeks before releasing them into shallow water. Millions of floating larvae may be produced by each female per spawn, but only a few survive to make their way back to continue their life on land.

∨ BUCCAL CAVITY
Setae on the outer mouthparts scrub food from particles of sand and pass it inwards to the mandibles

∧ EYE
The eyes are on long stalks and can be rotated in their sockets, providing all-round vision for locating food and avoiding predators.

∧ UNDERSIDE
The abdomen in males, as shown here, is narrow. In females it is broad and wide for carrying the egg mass.

∧ LEG JOINT
Leg joints move in one plane, like a human knee, but each one moves in a different plane, making the crab very agile.

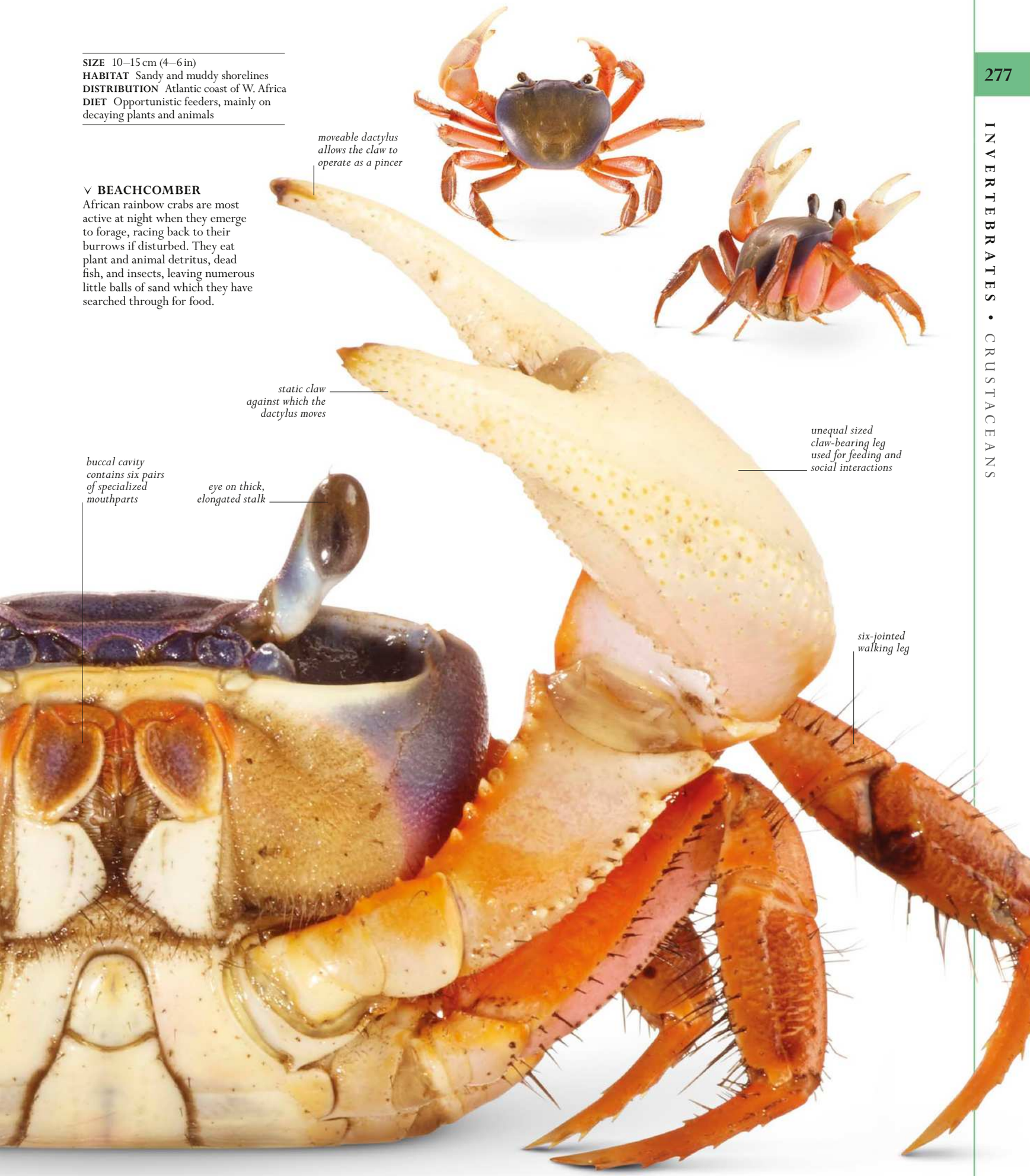
∧ SHELL
To increase in size the crab must shed its hard shell, a process called moulting. Water is absorbed into the body until the shell opens up and can be discarded, revealing a new, larger shell beneath.

one of eight walking legs
setae (stiff hairs) are sensitive to touch and help to detect food
sharp leg tip provides excellent dexterity

SIZE 10–15 cm (4–6 in)
HABITAT Sandy and muddy shorelines
DISTRIBUTION Atlantic coast of W. Africa
DIET Opportunistic feeders, mainly on decaying plants and animals

BEACHCOMBER

African rainbow crabs are most active at night when they emerge to forage, racing back to their burrows if disturbed. They eat plant and animal detritus, dead fish, and insects, leaving numerous little balls of sand which they have searched through for food.


moveable dactylus allows the claw to operate as a pincer
static claw against which the dactylus moves
unequal sized claw-bearing leg used for feeding and social interactions
buccal cavity contains six pairs of specialized mouthparts
eye on thick, elongated stalk
six-jointed walking leg

INSECTS

Insects first appeared on land more than 400 million years ago and today they account for more species than any other class on the planet.

Insects have evolved diverse lifestyles and although most are terrestrial, there are also numerous freshwater species but almost none are marine. They have a number of key features, such as a small size, an efficient nervous system, high reproductive rates, and – in many cases – the power of flight, which have led to their success.

Insects include (among others) beetles, flies, butterflies, moths, ants, bees, and true bugs. Yet for all their diversity, insects are remarkably similar. Evolution has modified the basic insect anatomy many times over to produce a multitude of variants based on three major body regions – the head, thorax, and abdomen. The head, made up of six fused segments, houses the brain and carries the major sensory organs: compound eyes, secondary light-receptive organs called ocelli, and the antennae. The mouthparts are modified according to diet, allowing the sucking of liquids or the chewing of solid foods.

The thorax is made up of three segments, each bearing a pair of legs. The posterior two thoracic segments usually each bear a pair of wings. The legs, which are each made up of a number of segments, can be greatly modified to serve a variety of functions from walking and running to jumping, digging, or swimming. The abdomen, which is usually made up of 11 segments, contains the digestive and reproductive organs.

PHYLUM	ARTHROPODA
CLASS	INSECTA
ORDERS	29
FAMILIES	About 1,000
SPECIES	About 1.1 million

DEBATE

HOW MANY SPECIES?

The actual number of insect species likely to exist far exceeds the 1.1 million so far described, and many more are discovered each year. However, research based on sampling in species-rich rainforests suggests that there could be as many as 10–12 million species of insects.

SILVERFISH

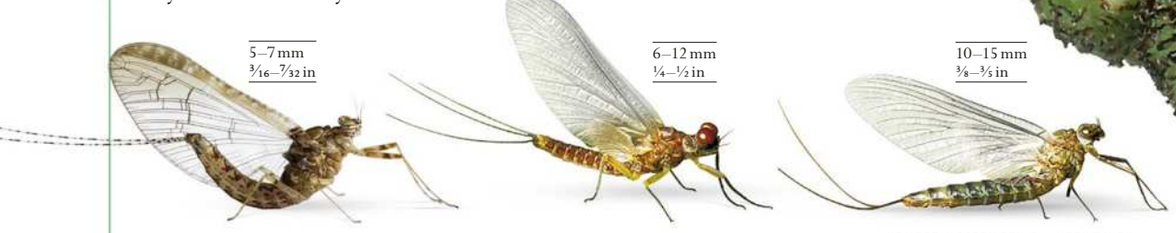
These primitive wingless insects in the order Zygentoma have a lengthy body that is covered with scales. The head has a pair of long antennae and small eyes. The abdominal segments have small appendages (styles).

SILVERFISH
Lepisma saccharina
F: Lepismatidae
This common domestic species can sometimes be a nuisance in kitchens, where it feeds on tiny scraps of dropped food.

FIREBRAT
Thermobia domestica
F: Lepismatidae
This insect is found worldwide and lives under stones and in leaf litter. Indoors, it favours warm conditions and can be a pest in bakeries.

MAYFLIES

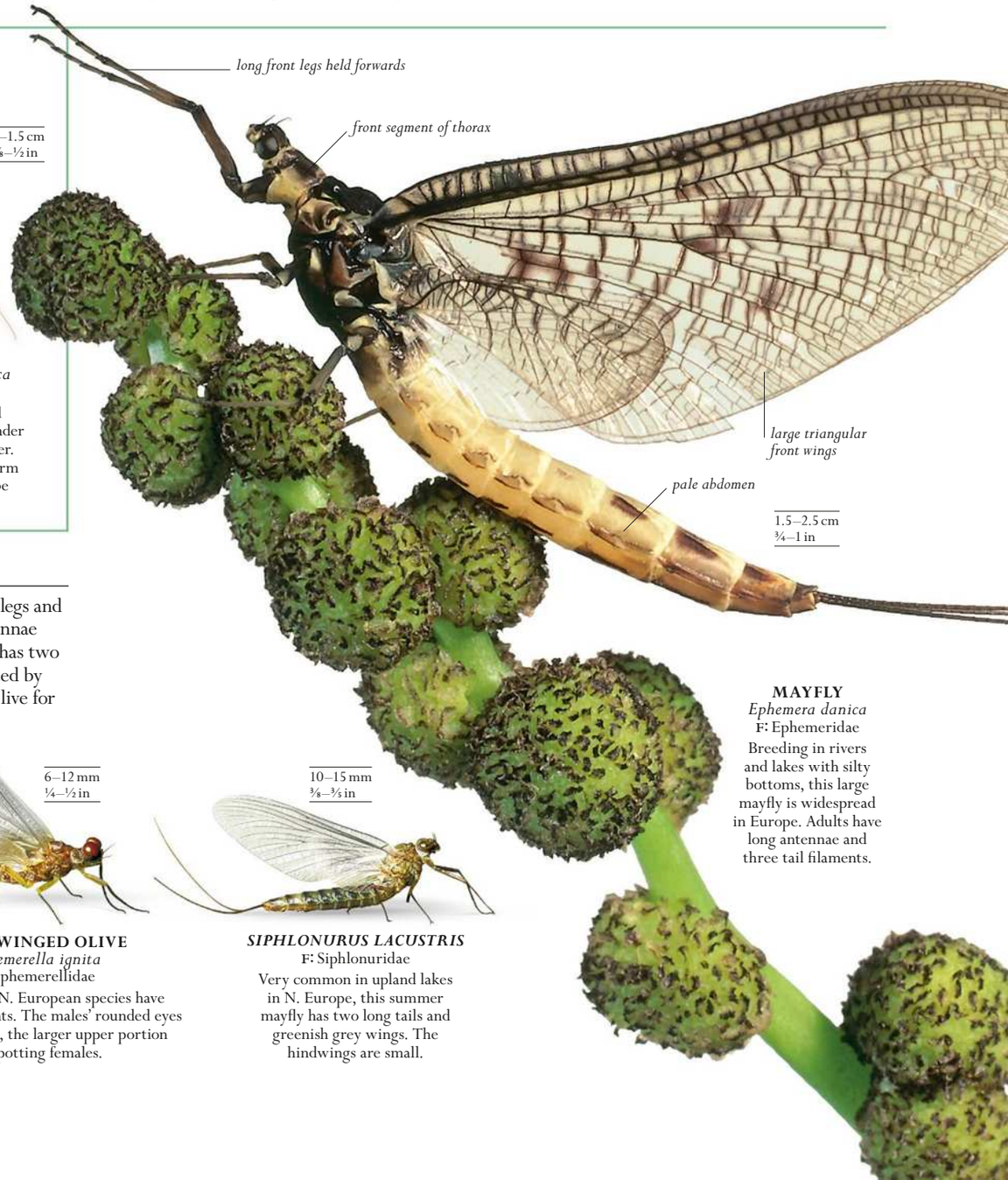
Ephemeroptera are soft-bodied insects with slender legs and two pairs of wings. The head has a pair of short antennae and large, compound eyes. The end of the abdomen has two or three long tail filaments. The life cycle is dominated by the aquatic nymphal stages – the non-feeding adults live for only a few hours or days.



POND OLIVE
Cloeon dipterum
F: Baetidae
A widespread European species, this mayfly breeds in a range of habitats from ponds and ditches to troughs and water butts.

BLUE-WINGED OLIVE
Ephemerella ignita
F: Ephemerellidae
Adults of this N. European species have three tail filaments. The males' rounded eyes have two parts, the larger upper portion for spotting females.

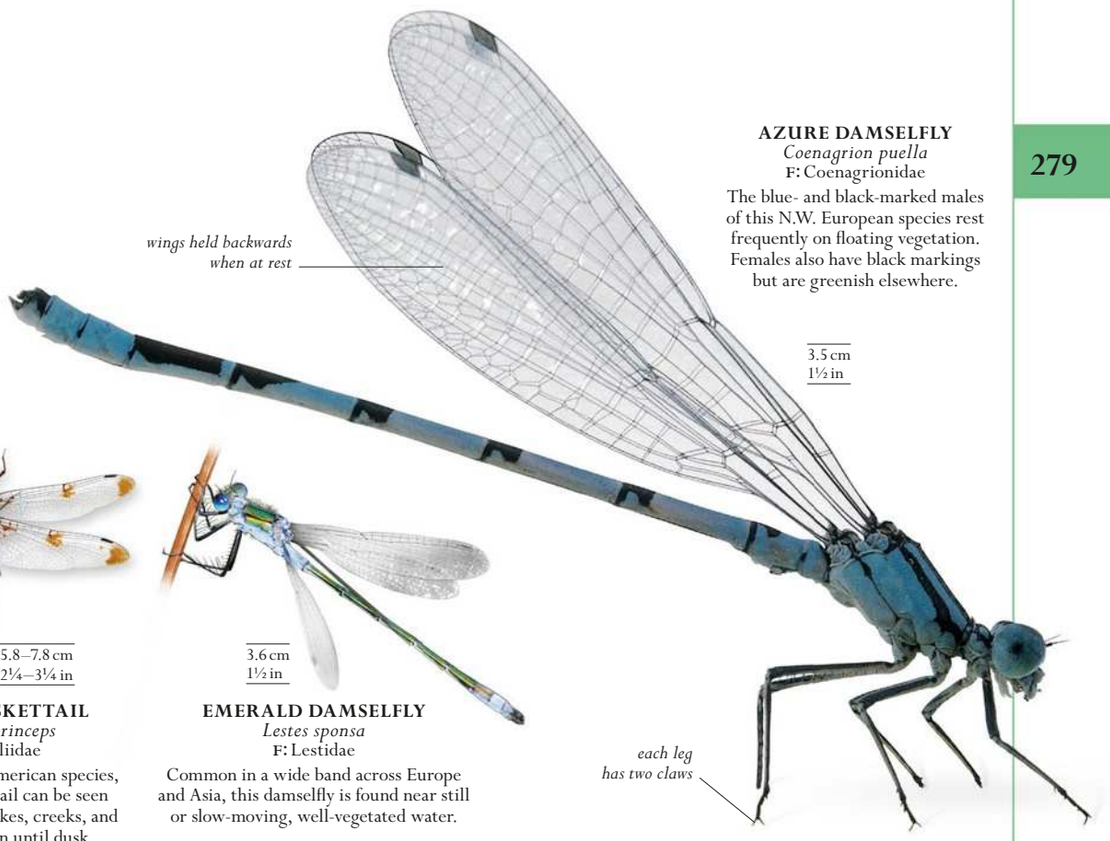
SIPHLONURUS LACUSTRIS
F: Siphlonuridae
Very common in upland lakes in N. Europe, this summer mayfly has two long tails and greenish grey wings. The hindwings are small.



MAYFLY
Ephemera danica
F: Ephemeridae
Breeding in rivers and lakes with silty bottoms, this large mayfly is widespread in Europe. Adults have long antennae and three tail filaments.

DAMSELFLIES AND DRAGONFLIES

These insects in the order Odonata have a distinctive long body with a mobile head and large eyes, giving good all-round vision. The adults have two pairs of similarly sized wings and are fast-flying hunters; the nymphs capture prey under water using their specialized mouthparts. Dragonflies are robust with a rounded head, whereas damselflies are more slender with a broader head and widely separated eyes.

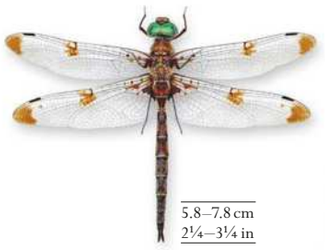


AZURE DAMSELFLY
Coenagrion puella
F: Coenagrionidae

The blue- and black-marked males of this N.W. European species rest frequently on floating vegetation. Females also have black markings but are greenish elsewhere.

TWIN-SPOTTED SPIKETAIL
Cordulegaster maculata
F: Cordulegastridae

This dragonfly is found in the E. USA and S.E. Canada, where it favours clean streams in wooded habitats.

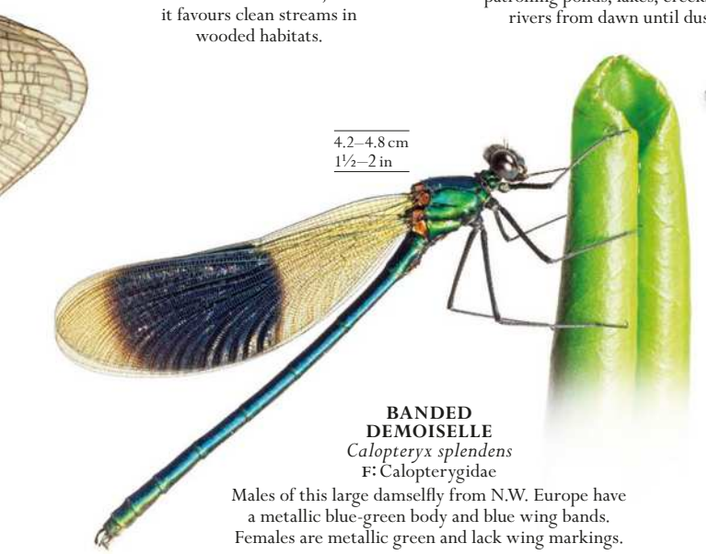


PRINCE BASKETTAIL
Epitheca princeps
F: Corduliidae

A widespread N. American species, the prince baskettail can be seen patrolling ponds, lakes, creeks, and rivers from dawn until dusk.

EMERALD DAMSELFLY
Lestes sponsa
F: Lestidae

Common in a wide band across Europe and Asia, this damselfly is found near still or slow-moving, well-vegetated water.

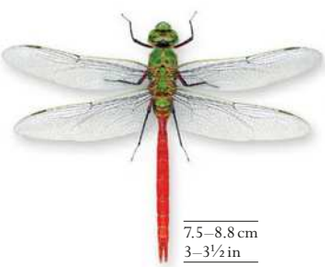


BANDED DEMOISELLE
Calopteryx splendens
F: Calopterygidae

Males of this large damselfly from N.W. Europe have a metallic blue-green body and blue wing bands. Females are metallic green and lack wing markings.

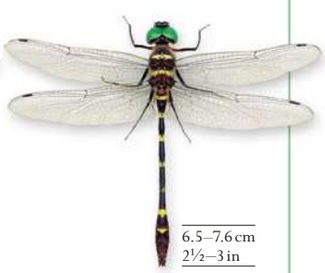
PLAINS CLUBTAIL
Gomphus externus
F: Gomphidae

Flying on warm sunny days and breeding in slow-moving, muddy streams and rivers, this dragonfly is widespread in the USA.



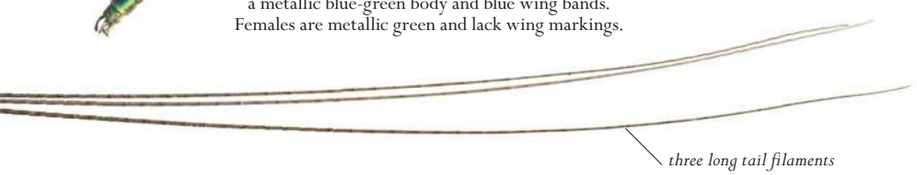
COMET DARNER
Anax longipes
F: Aeshnidae

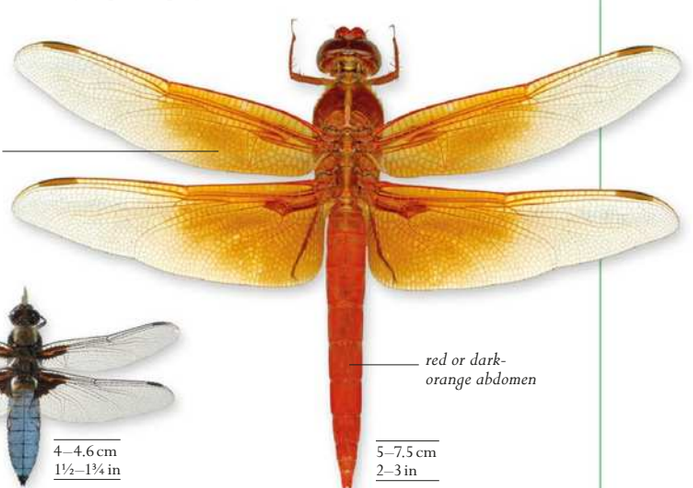
Occurring from Brazil to Massachusetts, the comet darner can be found over lakes and large ponds and has a steady, regular flight pattern.



ILLINOIS RIVER CRUISER
Macromia illinoiensis
F: Macromiidae

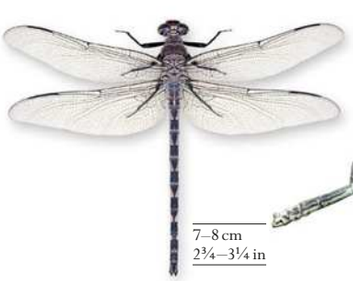
This N. American species patrols gravelly or rocky streams and rivers, but can also be seen flying away from water along roads or tracks.





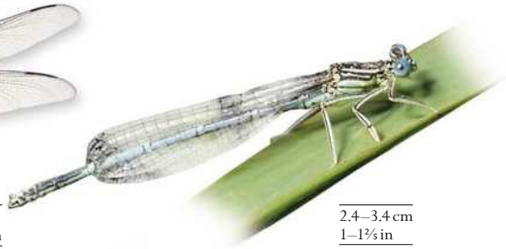
FLAME SKIMMER
Libellula saturata
F: Libellulidae

Favouring warm ponds, streams, and even hot springs, this species is common in the S.W. USA.



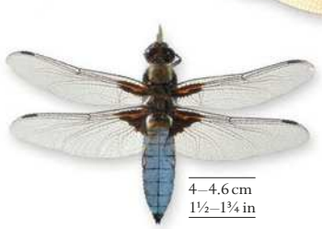
GRAY PETALTAIL
Tachopteryx thoreyi
F: Petaluridae

A large dragonfly found in damp broad-leaved forests of the east coast of N. America, this species breeds in boggy areas and seeps.



WHITE-LEGGED DAMSELFLY
Platycnemis pennipes
F: Platycnemididae

This damselfly from C. Europe breeds in slow-moving, weedy canals and rivers. The tibia of the hind leg is expanded and appears slightly feathery.



BROAD-BODIED CHASER
Libellula depressa
F: Libellulidae

This C. European and C. Asian species breeds in ditches and ponds. The abdomen of the male is blue above whereas that of the female is yellowish brown.

STONEFLIES

Members of the order Plecoptera are soft, slender-bodied insects with a pair of thin tail filaments and two pairs of wings. The nymphal stages are aquatic.

2–2.8 cm
¾–1 in

PERLA BIPUNCTATA
F: Perlidae

The males of this species, which favours stony streams in upland regions, have much shorter wings and can be half the size of the females.

0.9–1.3 cm
1/32–½ in

YELLOW SALLY
Isoperla grammatica
F: Perlodidae

Particularly common in limestone areas, this species prefers clean, gravel-bottomed streams and stony lakes. Males are shorter than females.

STICK AND LEAF INSECTS

These slow-moving herbivorous insects of the order Pseudophasmatidae have a stick- or leaf-like body that may be smooth or spiny. Many are well camouflaged to avoid predators.

TWO-STRIPED STICK INSECT
Anisomorpha buprestoides
F: Pseudophasmatidae

Found in the S. USA, this species can eject an acidic, defensive liquid from glands in the thorax.

4.2–6.8 cm
1½–2½ in

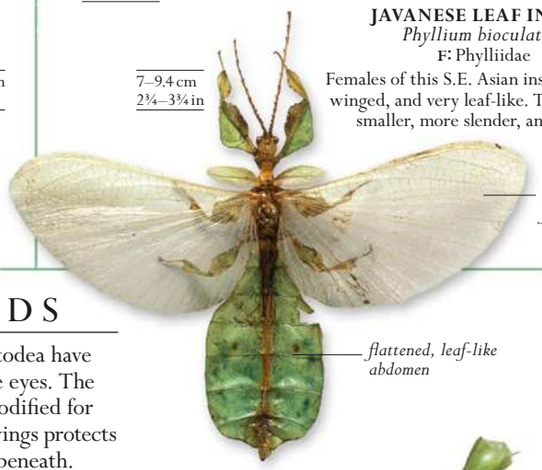
JUNGLE NYMPH STICK INSECT
Heteropteryx dilatata
F: Heteropterygidae

This impressive species is found in Malaysia. Females are flightless and green; males are smaller, winged, and brownish.

10–15.5 cm
4–6 in

JAVANESE LEAF INSECT
Phyllium bioculatum
F: Phylliidae

Females of this S.E. Asian insect are large, winged, and very leaf-like. The males are smaller, more slender, and brown.



7–9.4 cm
2¾–3¾ in

EARWIGS

These slender, slightly flattened, scavenging insects belong to the order Dermaptera. They have short front wings with large fan-shaped hindwings folded beneath. The flexible abdomen ends in a pair of multipurpose forceps.

1.2–1.5 cm
½–⅗ in

COMMON EARWIG
Forficula auricularia
F: Forficulidae

This species can be found under bark and in leaf litter. The female cares for her eggs and feeds the young nymphs.

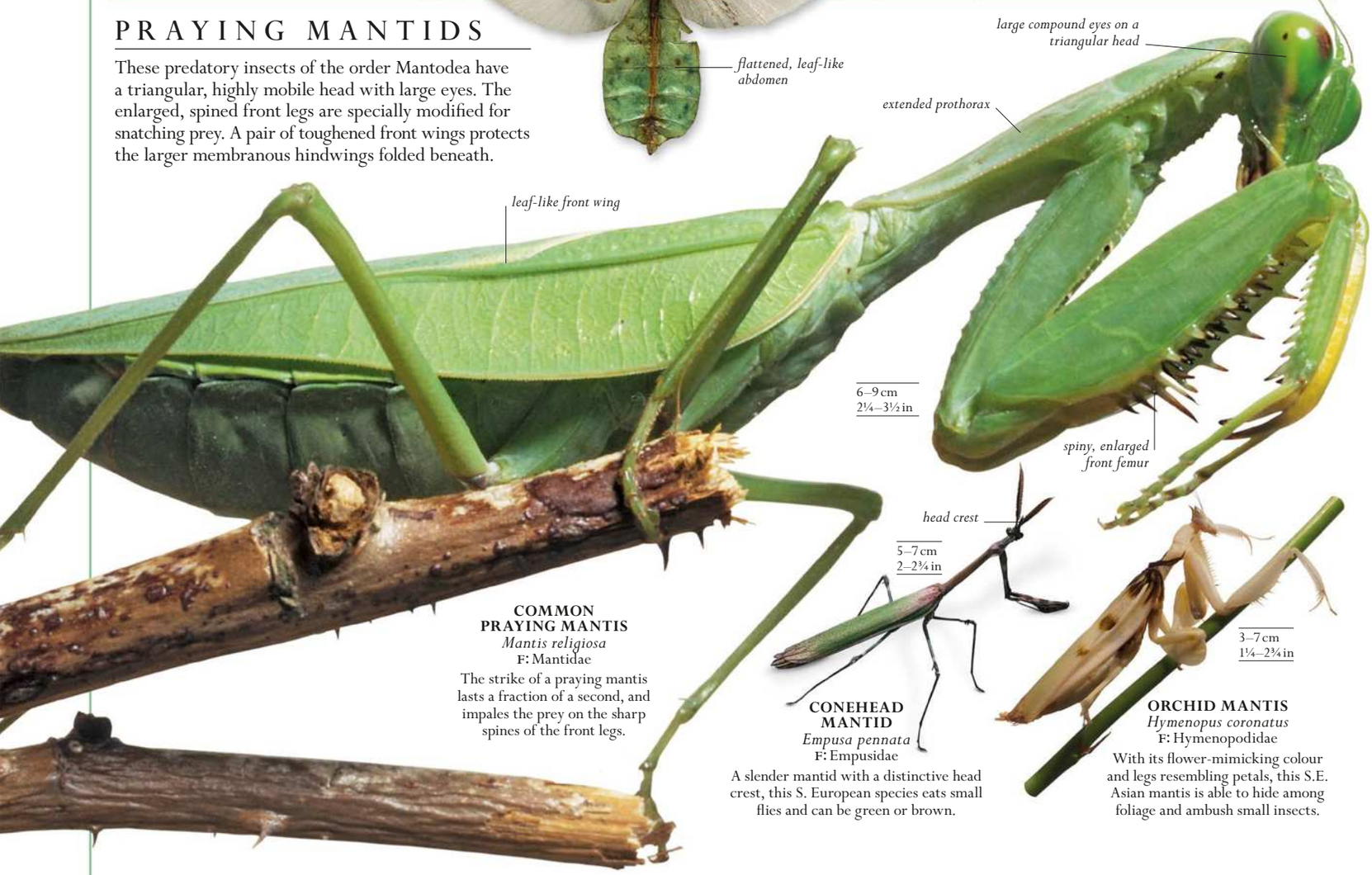
1.6–3 cm
½–1¼ in

TAWNY EARWIG
Labidura riparia
F: Labiduridae

The tawny earwig, the largest European species, is especially common along sandy river banks and in coastal areas.

PRAYING MANTIDS

These predatory insects of the order Mantodea have a triangular, highly mobile head with large eyes. The enlarged, spined front legs are specially modified for snatching prey. A pair of toughened front wings protects the larger membranous hindwings folded beneath.



COMMON PRAYING MANTIS
Mantis religiosa
F: Mantidae

The strike of a praying mantis lasts a fraction of a second, and impales the prey on the sharp spines of the front legs.

CONEHEAD MANTID
Empusa pennata
F: Empusidae

A slender mantid with a distinctive head crest, this S. European species eats small flies and can be green or brown.

ORCHID MANTIS
Hymenopus coronatus
F: Hymenopodidae

With its flower-mimicking colour and legs resembling petals, this S.E. Asian mantis is able to hide among foliage and ambush small insects.

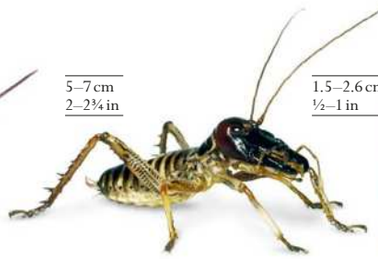
CRICKETS AND GRASSHOPPERS

Orthoptera are mainly herbivorous. They have two pairs of wings, although some can be short-winged or wingless. The hind legs are often large and used for jumping. They sing by rubbing their front wings together or their hind legs on a wing edge.

1.4–2.4 cm
½–1 in

COMMON FIELD GRASSHOPPER
Chorthippus brunneus
F: Acrididae

This grasshopper is typically found on short, dry, grazed grassland in Europe, N. Africa, and temperate Asia, where it is most active on sunny days.


5–7 cm
2–2¾ in

1.5–2.6 cm
½–1 in

WELLINGTON TREE WETA
Hemideina crassidens
F: Anostostomatidae

Native to New Zealand, this nocturnal insect lives in rotten wood and tree stumps. It eats plant material as well as small insects.

AFRICAN CAVE CRICKET
Phaeophilacris bredoides
F: Rhaphidophoridae

This C. African species is an omnivorous scavenger. It has very long antennae, an adaptation to life in dark micro-habitats.

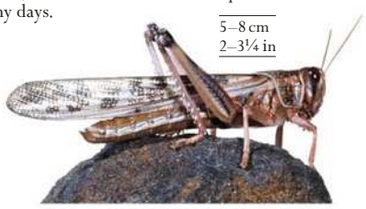
4 cm
1½ in

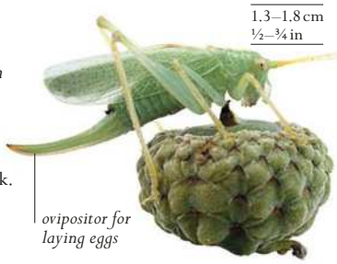
LEAF-ROLLING CRICKET
Hyalogryllacris subdebilis
F: Gryllacrididae

Found in Australia, this species has relatively long wings and very long antennae, which may be up to three times the length of the body.

DESERT LOCUST
Schistocerca gregaria
F: Acrididae

Crowding of nymphs after rain stimulates this African insect to transform from a solitary into a gregarious form. It swarms in billions, devastating crops.


5–8 cm
2–3¼ in


1.3–1.8 cm
½–¾ in

OAK BUSH CRICKET
Meconema thalassinum
F: Tettigoniidae

Found on a range of broadleaved trees, this European cricket feeds on small insects after dark. The female has a long, curved ovipositor.

ovipositor for laying eggs

3.5–4.6 cm
1½–1¾ in

MOLE CRICKET
Gryllotalpa gryllotalpa
F: Gryllotalpidae

This species from Europe uses its strong front legs to burrow, just like a miniature mole. It is found in meadows and banks near rivers, where the soil is damp and sandy.

warty surface

6–8 cm
2¼–3¼ in

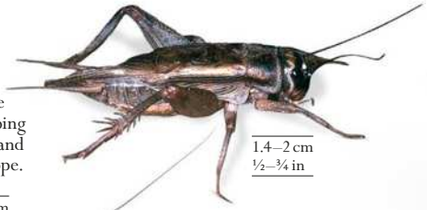
bright red markings

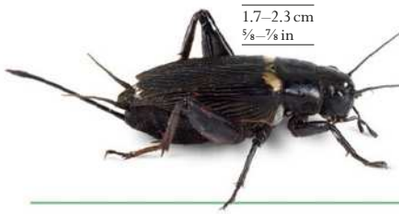
FOAMING GRASSHOPPER
Dictyophorus spumans
F: Pyrgomorphidae

Bright colours advertise that this South African grasshopper is toxic to predators. It can also produce a noxious foam from its thoracic glands.

HOUSE CRICKET
Acheta domesticus
F: Gryllidae

A nocturnal species, the house cricket makes an attractive chirping song. Originally from S.W. Asia and N. Africa it has spread into Europe.


1.4–2 cm
½–¾ in


1.7–2.3 cm
⅝–⅞ in

SOUTHERN FIELD CRICKET
Gryllus bimaculatus
F: Gryllidae

This cricket is widespread in S. Europe, parts of Africa, and Asia and lives on the ground under wood or debris.

COCKROACHES

Members of the order Blattodea are scavenging insects, with a flattened oval body. The downward-pointing head is often largely concealed by a shield-like pronotum and there are usually two pairs of wings. The tip of the abdomen has a pair of sensory organs, or cerci.

5–8 cm
2–3¼ in

MADAGASCAN HISSING COCKROACH
Gromphadorhina portentosa
F: Blaberidae

This large, wingless cockroach is reared worldwide as a pet. The male has prominent bumps on the thorax for male-to-male combat.

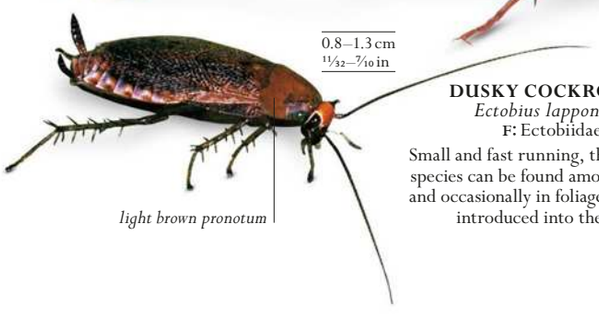
short terminal cerci

NYMPH

2.7–4.4 cm
1⅛–1¾ in

AMERICAN COCKROACH
Periplaneta americana
F: Blattidae

This species, which was originally from Africa, is now found worldwide. It lives on ships and in food warehouses.


0.8–1.3 cm
11/32–7/10 in

light brown pronotum

DUSKY COCKROACH
Ectobius lapponicus
F: Ectobiidae

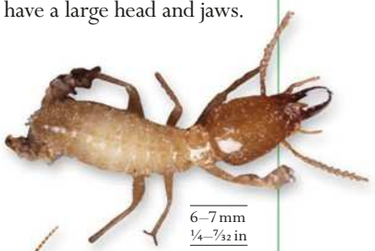
Small and fast running, this European species can be found among leaf litter and occasionally in foliage. It has been introduced into the USA.

TERMITES

These nest-building social insects of the order Isoptera live in colonies with different castes: reproductives (the kings and queens), workers, and soldiers. Workers are generally pale and wingless; reproductives have wings that are shed after a nuptial fight; and soldiers have a large head and jaws.

SUBTERRANEAN TERMITE
Coptotermes formosanus
F: Rhinotermitidae

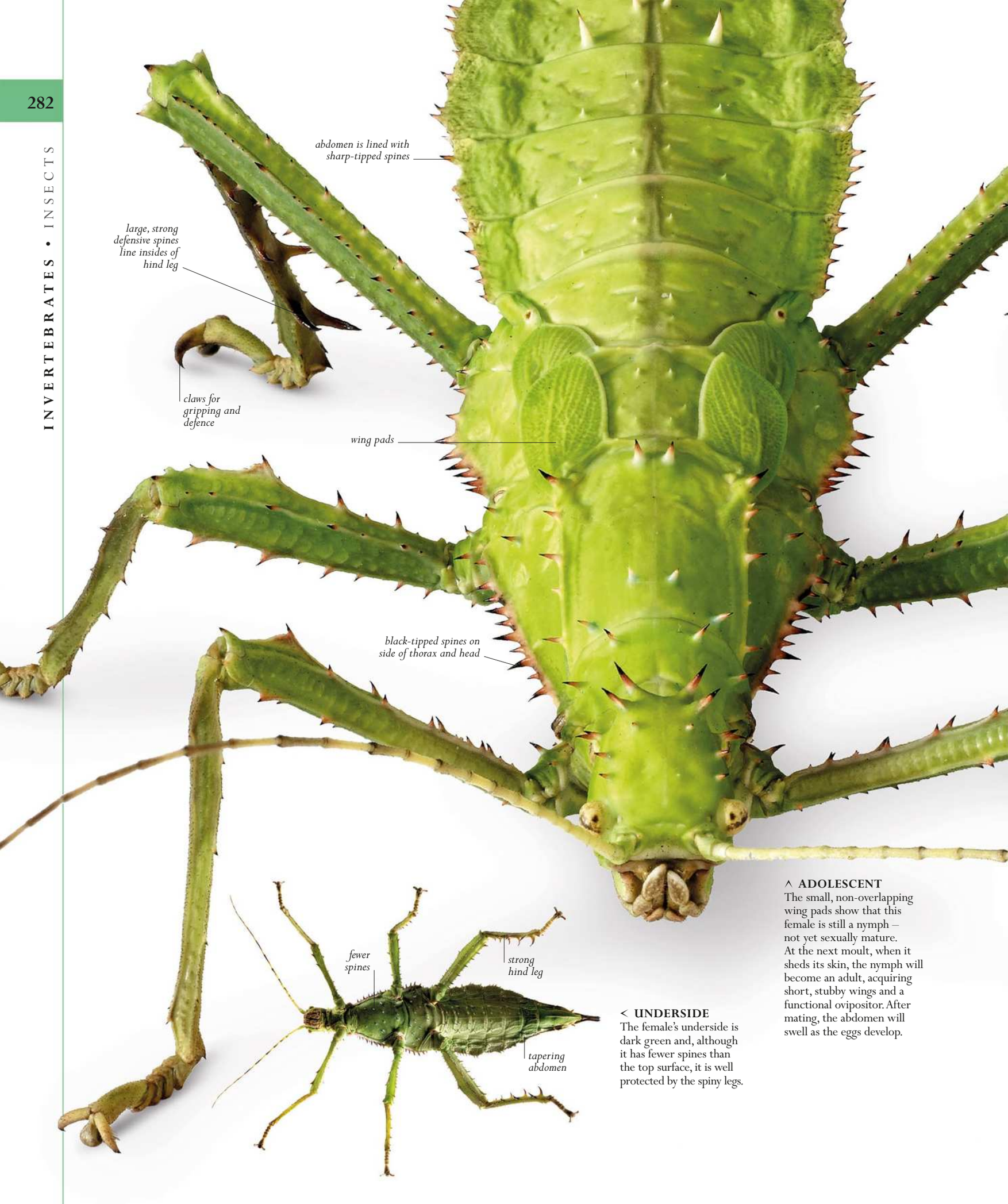
Native to S. China, Taiwan, and Japan, this invasive species has now spread to other parts of the world, where it is a serious pest.


6–7 mm
¼–7/32 in

0.8–1.5 cm
¼–½ in

PACIFIC DAMPWOOD TERMITE
Zootermopsis angusticollis
F: Archotermopsidae

This termite, found along the Pacific coastal states of N. America, nests in and feeds on decayed, fungus-infected wood.


abdomen is lined with sharp-tipped spines
large, strong defensive spines line insides of hind leg
claws for gripping and defence
wing pads
black-tipped spines on side of thorax and head
fewer spines
strong hind leg
tapering abdomen

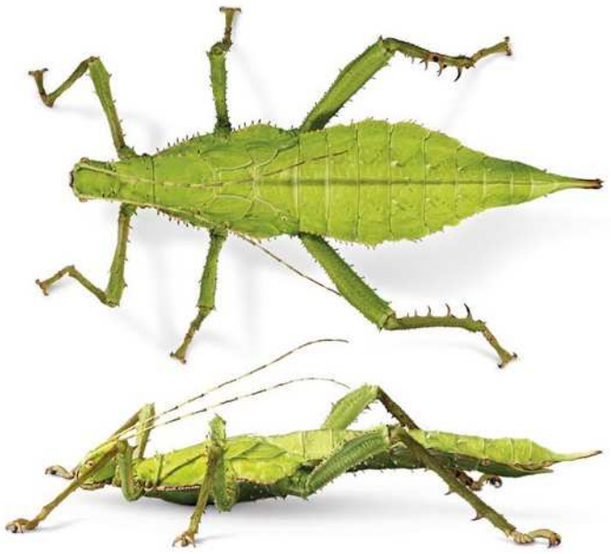
^ ADOLESCENT
The small, non-overlapping wing pads show that this female is still a nymph – not yet sexually mature. At the next moult, when it sheds its skin, the nymph will become an adult, acquiring short, stubby wings and a functional ovipositor. After mating, the abdomen will swell as the eggs develop.

< UNDERSIDE
The female's underside is dark green and, although it has fewer spines than the top surface, it is well protected by the spiny legs.

JUNGLE NYMPH STICK INSECT

Heteropteryx dilatata

This species is also known as the Malayan jungle nymph. Females are large, with bright green coloration on their upper surface and darker green below. The adult male is much smaller, more slender, and darker in colour. Both have wings, but the female is flightless. Nymphs and adults feed on the foliage of a range of different plants, including durian, guava, and mango. Mature females with eggs can be very aggressive. If disturbed, they make a loud hissing sound using their short wings, and splay their strong, spiny hind legs in a defensive posture. If attacked, they will kick out. This lively, nocturnal species has become a popular pet worldwide.



SIZE Up to 15.5 cm (6 in)
HABITAT Tropical forest
DISTRIBUTION Malaysia
DIET Foliage of various plants

MOUTHPARTS >
At rest the jaws are concealed behind two pairs of food-handling appendages called palps. These are covered with sensory organs, which enable the insect to taste the surface of the leaves it feeds on.

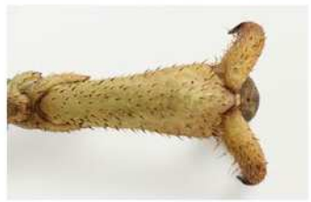
< COMPOUND EYE
Compound eyes – typical of insects – do not need to be as acute as those of many predatory arthropods, but they do need to be able to detect movement and potential enemies.

SEGMENTED BODY >
The tough, spiny plates that make up the body segments are joined by soft membranes that allow flexibility.

long, segmented antennae sense the immediate environment, including air movements

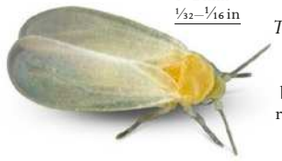
^ OVIPOSITOR
The female – which can lay up to 150 eggs in her lifetime – uses her ovipositor to lay her large eggs one at a time, concealed in leaf litter or moist soil.

^ > FOOT
The foot is made up of a number of short tarsal segments and a long, spiny terminal segment, which bears a pair of sharp, curved claws.



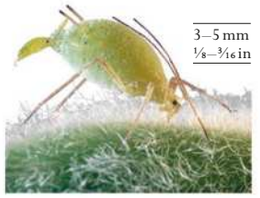
TRUE BUGS

Abundant and widespread in terrestrial and aquatic habitats, members of the order Hemiptera range from minute, wingless insects to giant water bugs capable of catching fish and frogs. The mouthparts are used for piercing and sucking up liquids such as plant sap, dissolved prey tissues, or blood. Many species are plant pests and some transmit disease.



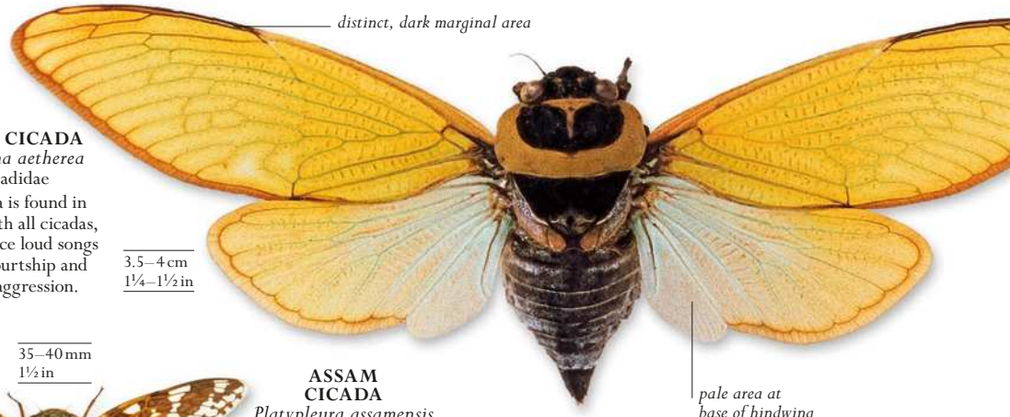
GLASSHOUSE WHITEFLY
Trialeurodes vaporariorum
F: Aleyrodidae

This small moth-like bug is found in temperate regions worldwide and can be a serious pest of glasshouse crops.



AMERICAN LUPIN APHID
Macrosiphum albifrons
F: Aphididae

Aphids such as this U.S. species can quickly infest plants because females can produce many offspring without fertilization.



INDIAN CICADA
Angamiana aetherea
F: Cicadidae

This cicada is found in India. As with all cicadas, males produce loud songs both for courtship and to signal aggression.

SPITTLE BUG
Aphrophora alni
F: Aphrophoridae

Commonly occurring on a wide range of trees and shrubs across Europe, this froghopper can vary in appearance from pale to dark brown.

FROGHOPPER
Cecopis vulnerata
F: Cercopidae

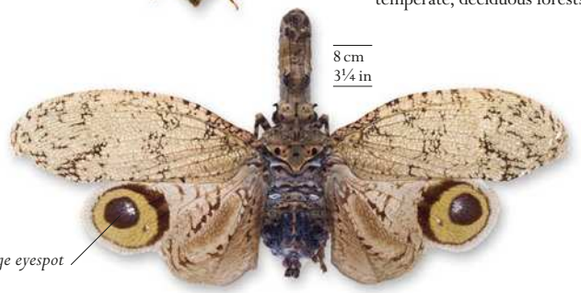
The nymphs of this conspicuously coloured European species live communally underground in a protective, frothy mass and feed on plant root sap.

ASSAM CICADA
Platypleura assamensis
F: Cicadidae

Known from N. India, this species is also found in Bhutan and parts of China where it prefers temperate, deciduous forests.

HORSE CHESTNUT SCALE
Pulvinaria regalis
F: Coccidae

Although commonly found on the bark of horse chestnut trees, this European scale insect will also attack a range of other deciduous species.

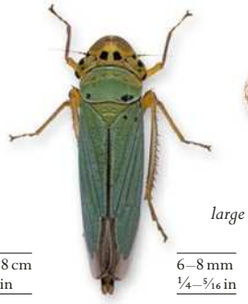


PEANUT-HEADED BUG
Fulgora laternaria
F: Fulgoridae

This bug is found in C. and S. America and the West Indies. The bulbous head was once thought to glow.

LEAFHOPPER
Ledra aurita
F: Cicadellidae

Mottled coloration helps this flat-bodied leafhopper from N. Europe to blend with the lichen-covered bark of oak trees in its habitat.

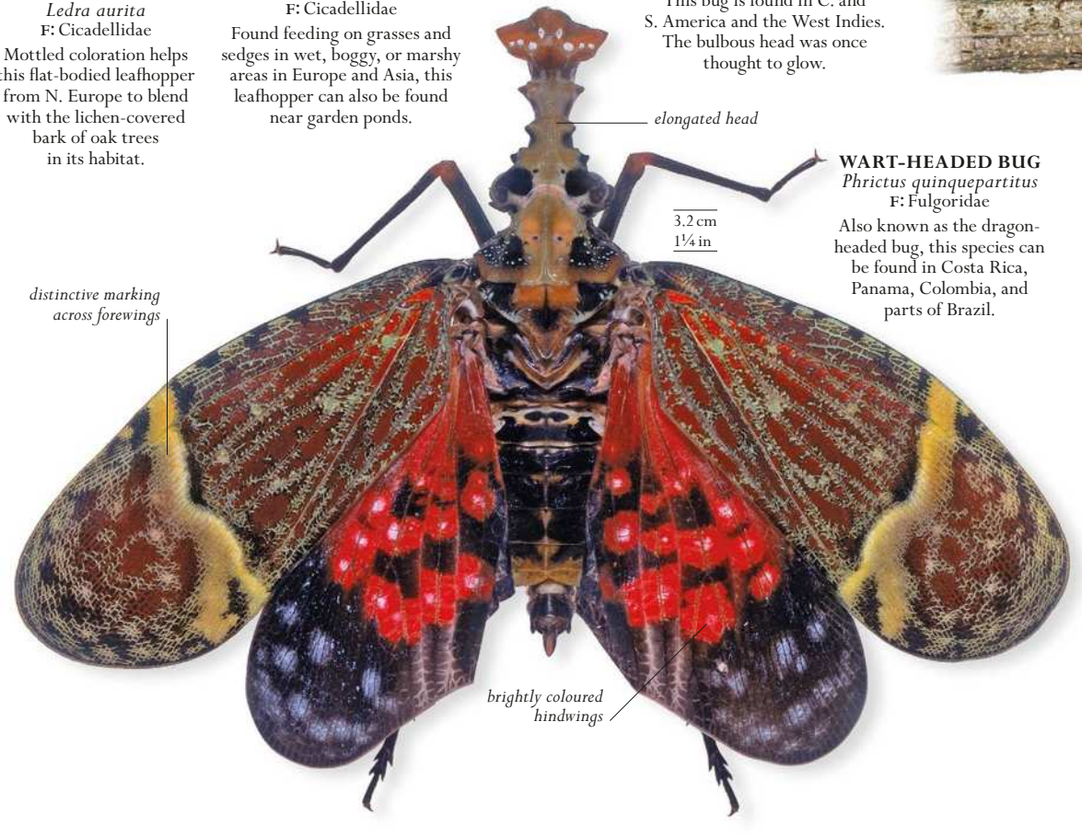


CICADELLA VIRIDIS
F: Cicadellidae

Found feeding on grasses and sedges in wet, boggy, or marshy areas in Europe and Asia, this leafhopper can also be found near garden ponds.

THORN BUG
Umbonia crassicornis
F: Membracidae

Found in C. and S. America, almost the whole body of this bug is concealed under the enlarged, thorn-like pronotum.



WART-HEADED BUG
Phrictus quinquepartitus
F: Fulgoridae

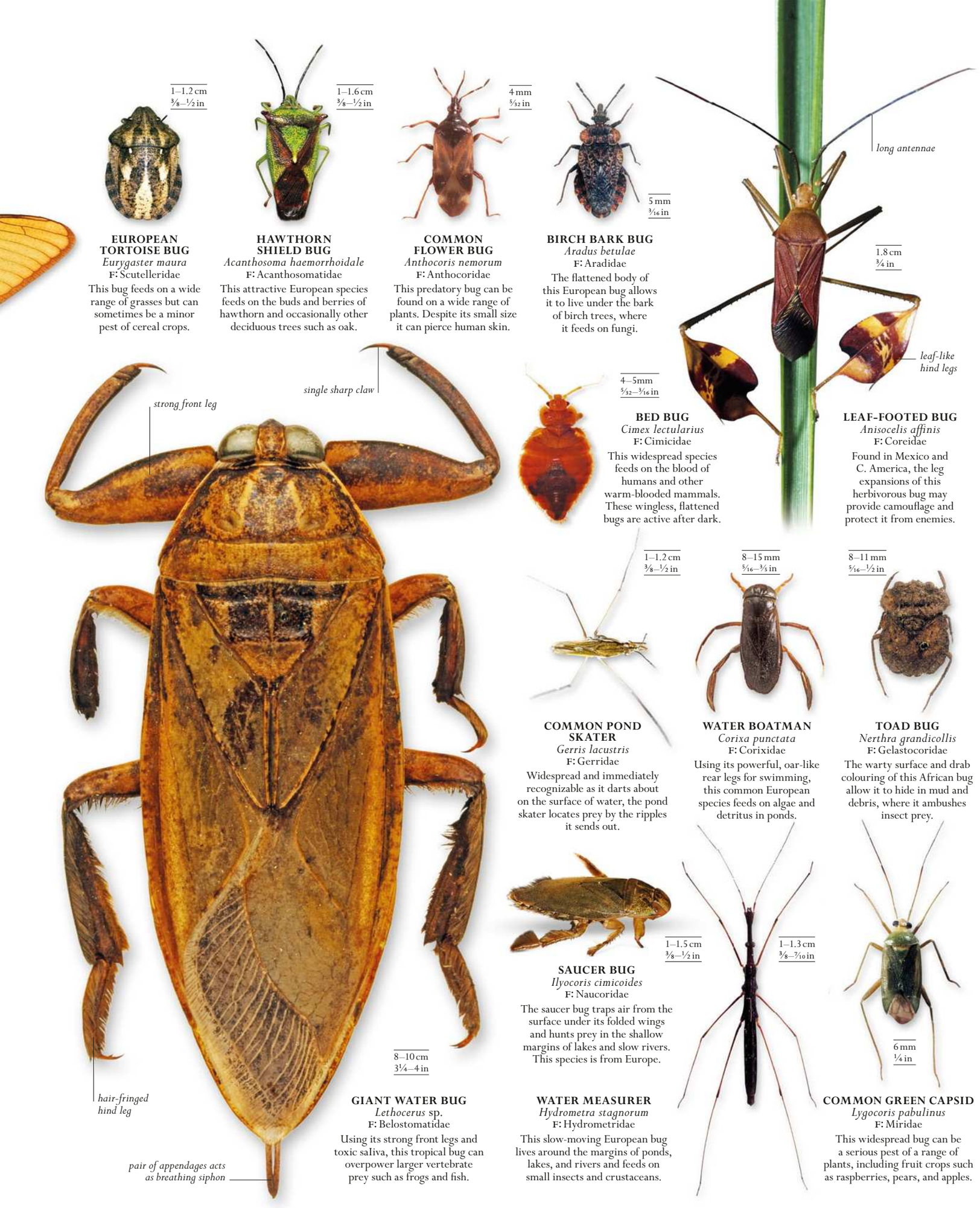
Also known as the dragon-headed bug, this species can be found in Costa Rica, Panama, Colombia, and parts of Brazil.

ASH PLANT LOUSE
Psyllopsis fraxini
F: Psyllidae

Found commonly on ash trees, the nymphs of this species cause the edges of leaves to form red, swollen galls when they feed.

THISTLE LACE BUG
Tingis cardui
F: Tingidae

This bug occurs in most of Europe and feeds on spear, musk, and marsh thistles. The body is covered in powdery wax.



EUROPEAN TORTOISE BUG
Eurygaster maura
F: Scutelleridae

This bug feeds on a wide range of grasses but can sometimes be a minor pest of cereal crops.

HAWTHORN SHIELD BUG
Acanthosoma haemorrhoidale
F: Acanthosomatidae

This attractive European species feeds on the buds and berries of hawthorn and occasionally other deciduous trees such as oak.

COMMON FLOWER BUG
Anthocoris nemorum
F: Anthocoridae

This predatory bug can be found on a wide range of plants. Despite its small size it can pierce human skin.

BIRCH BARK BUG
Aradus betulae
F: Aradidae

The flattened body of this European bug allows it to live under the bark of birch trees, where it feeds on fungi.

LEAF-FOOTED BUG
Anisocelis affinis
F: Coreidae

Found in Mexico and C. America, the leg expansions of this herbivorous bug may provide camouflage and protect it from enemies.

BED BUG
Cimex lectularius
F: Cimicidae

This widespread species feeds on the blood of humans and other warm-blooded mammals. These wingless, flattened bugs are active after dark.

COMMON POND SKATER
Gerris lacustris
F: Gerridae

Widespread and immediately recognizable as it darts about on the surface of water, the pond skater locates prey by the ripples it sends out.

WATER BOATMAN
Corixa punctata
F: Corixidae

Using its powerful, oar-like rear legs for swimming, this common European species feeds on algae and detritus in ponds.

TOAD BUG
Nerthra grandicollis
F: Gelastocoridae

The warty surface and drab colouring of this African bug allow it to hide in mud and debris, where it ambushes insect prey.

SAUCER BUG
Ilyocoris cimicoides
F: Naucoridae

The saucer bug traps air from the surface under its folded wings and hunts prey in the shallow margins of lakes and slow rivers. This species is from Europe.

GIANT WATER BUG
Lethocerus sp.
F: Belostomatidae

Using its strong front legs and toxic saliva, this tropical bug can overpower larger vertebrate prey such as frogs and fish.

WATER MEASURER
Hydrometra stagnorum
F: Hydrometridae

This slow-moving European bug lives around the margins of ponds, lakes, and rivers and feeds on small insects and crustaceans.

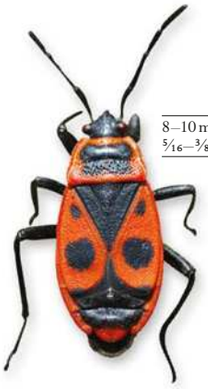
COMMON GREEN CAPSID
Lygocoris pabulinus
F: Miridae

This widespread bug can be a serious pest of a range of plants, including fruit crops such as raspberries, pears, and apples.

» TRUE BUGS

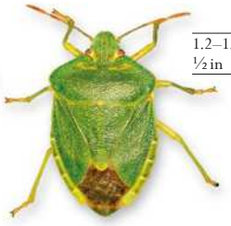
SCARLET SHIELD BUG
Eurydema dominulus
F: Pentatomidae

This European species, which can be red or orange, feeds on plants of the cress family and can be a pest of brassicas.



FIRE BUG
Pyrrhocoris apterus
F: Pyrrhocoridae

This unmistakable black and red bug is a gregarious, flightless species widespread in C. and S. Europe. It feeds on seeds.



COMMON GREEN SHIELD BUG
Palomena prasina
F: Pentatomidae

This bug is very common and widespread across Europe. It feeds on a wide range of plants and can be a minor pest.

FOREST BUG
Pentatoma rufipes
F: Pentatomidae

Found on a range of deciduous trees, this European species, recognizable by its blunt-shouldered appearance, feeds on sap and small insects.

strong front legs for holding prey
spine at side of thorax
false "eye" spot on front wing
reddish orange leg band
2–4 cm
¾–1½ in

WHITE-SPOTTED ASSASSIN BUG
Platymeris biguttata
F: Reduviidae

Like all assassin bugs, this African species has toxic saliva, but unlike many it can spit its saliva, causing temporary blindness.

WATER STICK INSECT
Ranatra linearis
F: Nepidae

Using its specialized, long front legs to catch prey, including small fish, this slender bug favours deeper, well-vegetated pools.

WATER SCORPION
Nepa cinera
F: Nepidae

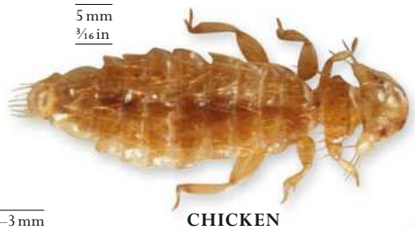
This aquatic bug crawls about in the margins of shallow pools to catch small prey. It breathes through a long respiratory tail.

COMMON BACKSWIMMER
Notonecta glauca
F: Notonectidae

Found in ponds, lakes, canals, and ditches in Europe, this species is capable of taking vertebrate prey such as tadpoles and small fish. The underside faces up as it swims.

PARASITIC LICE

These wingless insects of the order Phthiraptera are ectoparasites, living on the bodies of birds and mammals. Their mouthparts are modified for chewing skin fragments or sucking blood, and their legs for gripping tightly to hair or feathers.

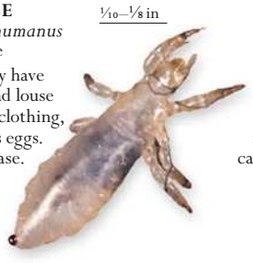


CHICKEN BODY LOUSE
Menacanthus stramineus
F: Menoponidae

Found worldwide as an ectoparasite of chickens, infestations of this pale, flattened chewing louse can cause feather loss and infection.

HUMAN HEAD LOUSE
Pediculus humanus capitis
F: Pediculidae

This louse glues its eggs, called "nits", to head hair. Infestation outbreaks are common among school children. A related species attacks chimpanzees.



HUMAN BODY LOUSE
Pediculus humanus humanus
F: Pediculidae

This subspecies may have evolved from the head louse after the invention of clothing, to which it glues its eggs. It transmits disease.

GOAT LOUSE
Damalinia caprae
F: Trichodectidae

Found worldwide on goats, this biting louse can also survive for a few days on sheep but is not able to breed on them.

BARKLICE AND BOOKLICE

Common on vegetation and in litter, insects of the order Psocoptera are small, squat, and soft-bodied. The head has thread-like antennae and bulging eyes. They eat microflora and some species are pests of stored products.

4–6 mm
5/32–1/4 in

PSOCOCERASTIS GIBBOSA
F: Psocidae
Native to Europe and parts of Asia, this relatively large bark louse can be found on a wide range of deciduous and coniferous trees.

0.6–1.5 mm
1/64–1/24 in

LIPOSCELIS LIPARIUS
F: Liposcelididae
This very widespread species favours dark, damp micro-habitats and can be a pest in libraries and granaries if the humidity is too high.

THRIPS

Members of the order Thysanoptera are tiny insects, typically with two pairs of narrow, hair-fringed wings. They have large compound eyes and distinctive mouthparts for piercing and sucking.

1–1.5 mm
1/32–1/24 in

FLOWER THRIP
Frankliniella sp.
F: Thripidae
Flower thrips are found all over the world and can be pests on crops such as groundnut, cotton, sweet potato, and coffee.

SNAKEFLIES

Snakeflies, in the order Raphidioptera, are woodland insects with a long prothorax, a broad head, and two pairs of wings. Adults and larvae eat aphids and other soft prey.

1.6–1.8 cm
1/2–3/4 in

RAPHIDIA NOTATA
F: Raphidiidae
Found in deciduous or coniferous woodlands in Europe, this snakefly is usually associated with oak trees, where it eats aphids.

ALDERFLIES AND DOBSONFLIES

The Megaloptera have two pairs of wings, which are held roof-like over the body when they are at rest. The aquatic larvae, which are predatory and have abdominal gills, pupate on land in soil, moss, or rotting wood.

EASTERN DOBSONFLY
Corydalus cornutus
F: Corydalidae
Found in N. America, the male of this species has very long mandibles used for combat and for gripping the female.

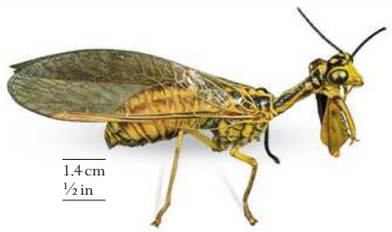
10–14 cm
4–5 1/2 in

ALDERFLY
Sialis lutaria
F: Sialidae
The female of this widespread species lays a mass of up to 2,000 eggs on twigs or leaves near water.

1.4–2.6 cm
1/2–1 in

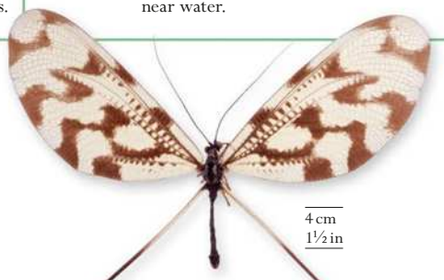
LACEWINGS AND RELATIVES

Insects of the order Neuroptera have conspicuous eyes and biting mouthparts. The pairs of net-veined wings are held roof-like over the body at rest. The larvae have sickle-shaped mouthparts, which form sharp, sucking tubes.



1.4 cm
1/2 in

MANTISPA STYRIACA
F: Mantispidae
Like a miniature praying mantid, this species, found in S. and C.Europe, lives in lightly wooded areas, where it hunts small flies.



4 cm
1 1/2 in

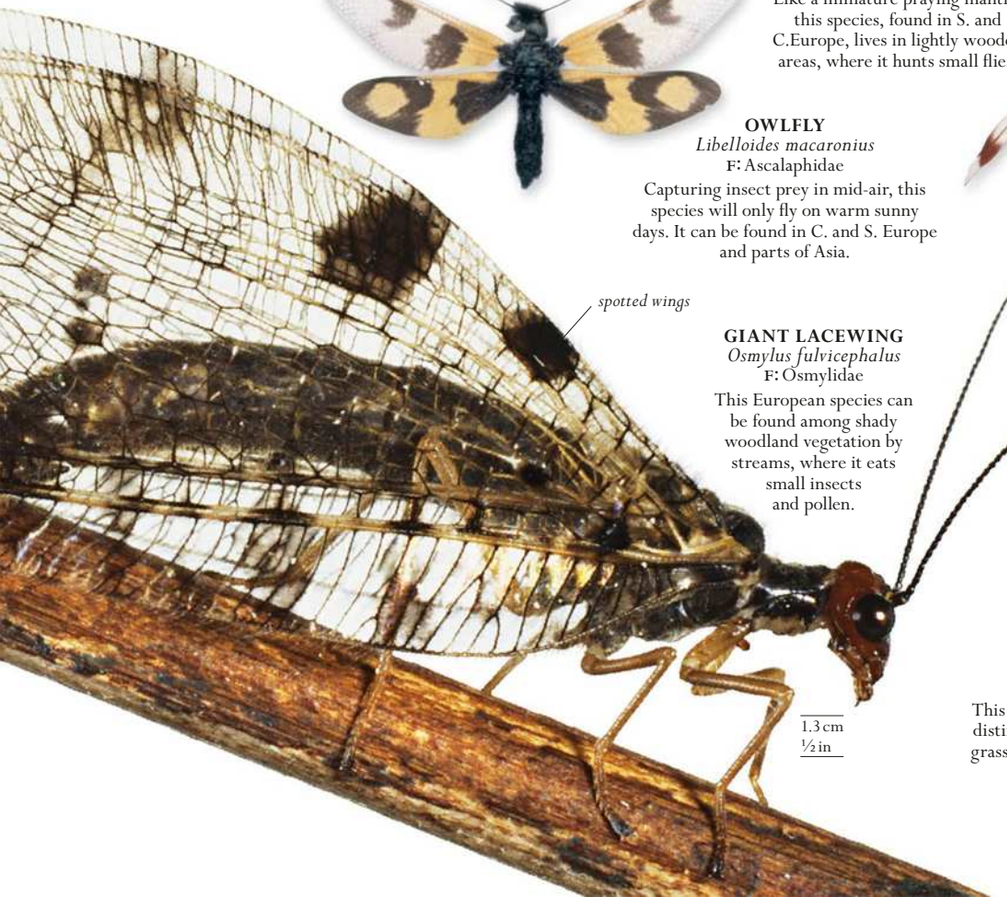
SPOON-WINGED LACEWING
Nemoptera sinuata
F: Nemopteridae
Common to areas of S.E. Europe, this delicate species feeds on nectar and pollen at flowers in woodland and open grassland.

3 cm
1 1/4 in

OWLFLY
Libelloides macaronius
F: Ascalaphidae
Capturing insect prey in mid-air, this species will only fly on warm sunny days. It can be found in C. and S. Europe and parts of Asia.

1–1.2 cm
3/8–1/2 in

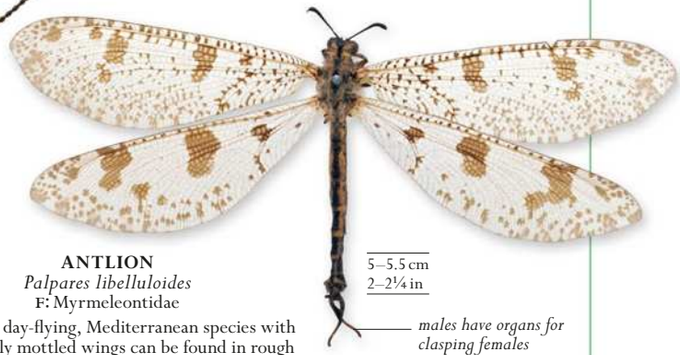
GREEN LACEWING
Chrysopa perla
F: Chrysopidae
This widespread European species has a characteristic bluish green tinge and black markings and is commonly found in deciduous woodland.



spotted wings

GIANT LACEWING
Osmylus fulvicephalus
F: Osmylidae
This European species can be found among shady woodland vegetation by streams, where it eats small insects and pollen.

1.3 cm
1/2 in



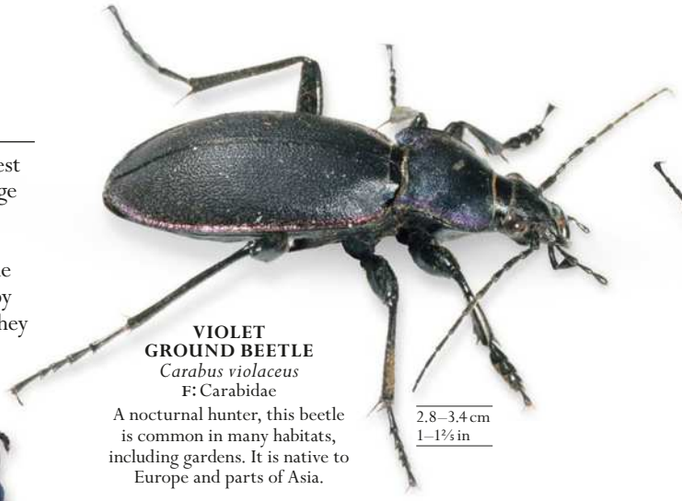
5–5.5 cm
2–2 1/4 in

males have organs for clasping females

ANTLION
Palpares libelluloides
F: Myrmeleontidae
This large, day-flying, Mediterranean species with distinctively mottled wings can be found in rough grassland, warm scrubby habitats, and sand dunes.

BEETLES

Members of the order Coleoptera – the largest insect order – range from minute to very large species. A distinguishing feature are the toughened front wings, called elytra, which meet down the body's midline and protect the larger membranous hindwings. Beetles occupy every aquatic and terrestrial habitat, where they are scavengers, herbivores, or predators.



VIOLET GROUND BEETLE
Carabus violaceus
F: Carabidae

A nocturnal hunter, this beetle is common in many habitats, including gardens. It is native to Europe and parts of Asia.

2.8–3.4 cm
1–1⅖ in

3–5 mm
⅛–3⁄16 in

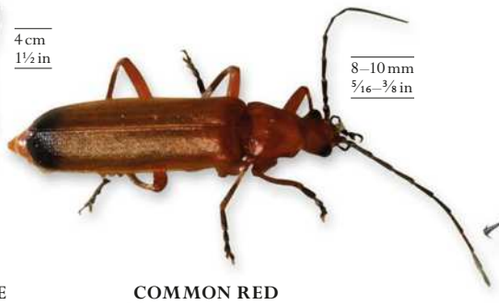
WOODWORM BEETLE
Anobium punctatum
F: Anobiidae

Adapted to breeding in timber in buildings and furniture, this species is now widespread and can be a serious pest.

4 cm
1½ in

JEWEL BEETLE
Chrysochroa chinensis
F: Buprestidae

This metallic species is native to India and S.E. Asia, where its larvae burrow into the wood of deciduous trees.



8–10 mm
5⁄16–⅜ in

COMMON RED SOLDIER BEETLE
Rhagonycha fulva
F: Cantharidae

A common sight on flowers in the summer, this European beetle can be found in meadows and woodland margins.

VIOLIN BEETLE
Mormolyce phyllodes
F: Carabidae

The shape of this S.E. Asian beetle allows it to squeeze under bracket fungi and tree bark, where it feeds on insect larvae and snails.

6–10 cm
2¼–4 in

7–10 mm
7⁄32–⅜ in

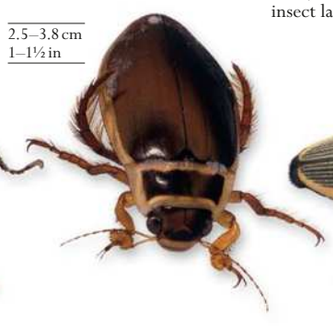
ANT BEETLE
Thanasimus formicarius
F: Cleridae

Associated with coniferous trees in Europe and N. Asia, the larvae and adults of this beetle prey on bark beetle larvae.

8–10 mm
5⁄16–⅜ in

LARDER BEETLE
Dermestes lardarius
F: Dermestidae

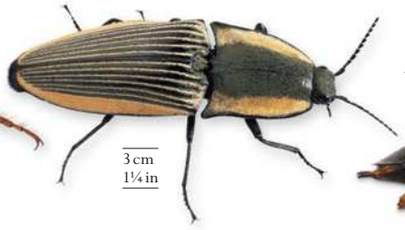
Found in Europe and parts of Asia, this beetle feeds on animal remains but also lives in buildings, where it eats stored produce.



2.5–3.8 cm
1–1½ in

GREAT DIVING BEETLE
Dytiscus marginalis
F: Dytiscidae

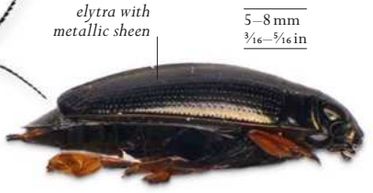
This large beetle lives in weedy ponds and lakes in Europe and N. Asia. It eats insects, frogs, newts, and small fish.



3 cm
1¼ in

CLICK BEETLE
Chalcolepidius limbatus
F: Elateridae

This beetle is found in woodland and grassland in the warmer parts of S. America. Its larvae are predators in rotten wood and soil.



5–8 mm
3⁄16–5⁄16 in

WHIRLIGIG BEETLE
Gyrinus marinus
F: Gyrinidae

A common European species, this beetle is a surface-dweller on ponds and lakes. It uses its paddle-shaped legs to skim over the water.

8–11mm
5⁄16–⅜ in

SCREECH BEETLE
Hygrobia hermanni
F: Hygrobiidae

This European beetle feeds on small invertebrate prey in slow-moving rivers and muddy ponds. It makes a high-pitched grating noise if handled.

2.5 cm
1 in

COMMON GLOW-WORM
Lampyris noctiluca
F: Lampyridae

This beetle is found across Europe and Asia, where it favours rough grassland. The wingless female – known as a glow-worm – emits a greenish light to attract a mate.

6–10 mm
¼–⅜ in

FOUR-SPOTTED HISTER BEETLE
Hister quadrimaculatus
F: Histeridae

Widespread across Europe, this beetle is found in dung and sometimes carrion, where it feeds on small insects and their larvae.

1.5–2 cm
½–¾ in

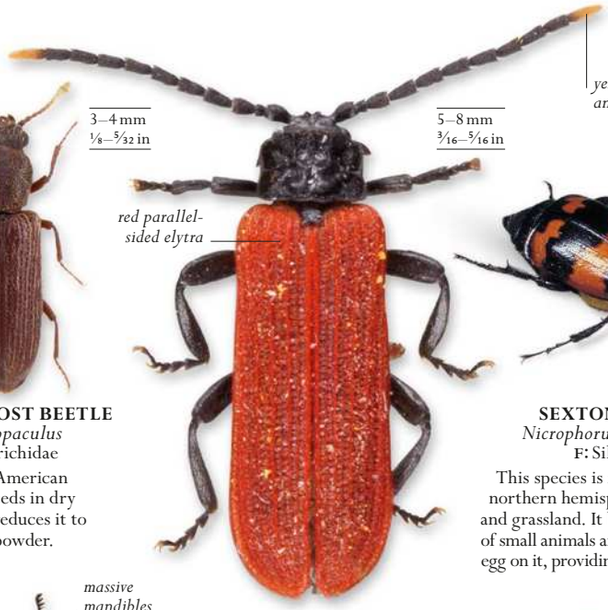
MINOTAUR BEETLE
Typhaeus typhoeus
F: Geotrupidae

This species is found in sandy areas in W. Europe and buries sheep and rabbit droppings, on which the larvae feed, in burrows.

3–4 mm
⅛–5⁄32 in

POWDER POST BEETLE
Lyctus opaculus
F: Bostrichidae

This N. American beetle breeds in dry wood and reduces it to a fine powder.



NET-WINGED BEETLE
Platycis minutus
F: Lycidae

This small beetle is associated with decaying wood in mature and ancient woodland across Eurasia.

2.6 cm
1 in

SEXTON BEETLE
Nicrophorus investigator
F: Silphidae

This species is found all over the northern hemisphere in woodland and grassland. It buries the carcasses of small animals and the female lays an egg on it, providing food for the larva.

6–17 cm
2¼–6½ in

HERCULES BEETLE
Dynastes hercules
F: Scarabaeidae

The largest species of rhinoceros beetle (genus *Dynastes*), this beetle feeds on rotting fruits in rainforests in C. and S. America. Its larvae breed in decaying wood.

5.5–10 cm
2¼–4 in

GOLIATH BEETLE
Goliathus cacicus
F: Scarabaeidae

This species, the world's heaviest insect, lives in equatorial Africa, where the adults feed on ripe fruits or tree sap.

STAG BEETLE
Lucanus cervus
F: Lucanidae

This impressive beetle lives in woodland in S. and C. Europe. Its larvae develop over 4–6 years, mainly in decaying oak stumps. Males use their enlarged, antler-like mandibles in contests over females.

4–6 mm
5⁄32–¼ in

SAP BEETLE
Glischrochilus hortensis
F: Nitidulidae

Often found feeding at fermenting sap flows or ripe fruits, this W. European member of the pollen beetle family is associated with decaying trees such as birch.

1–2.1 cm
⅜–¾ in

PHANAEUS DEMON
F: Scarabaeidae

Native to C. America, this very variable beetle breeds in the dung of large herbivorous animals in grassland and pasture.

DEVIL'S COACH HORSE
Staphylinus olens
F: Staphylinidae

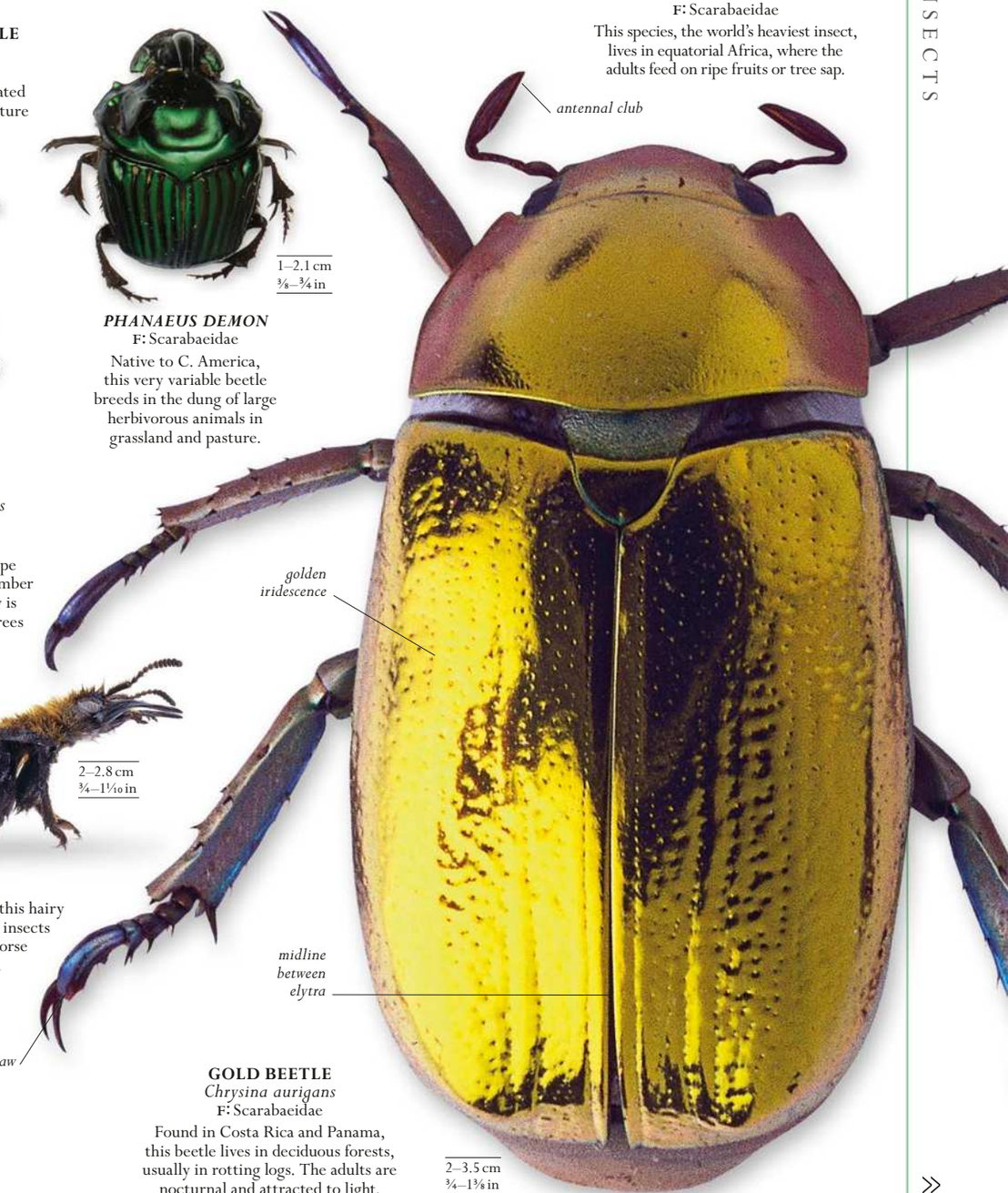
A European species found among woodland and garden leaf litter, this beetle raises its abdomen in a threatening display if disturbed.

2–3.2 cm
¾–1¼ in

2–2.8 cm
¾–1⁹⁄10 in

EMUS HIRTUS
F: Staphylinidae

Native to S. and C. Europe, this hairy rove beetle feeds on other insects attracted to cow and horse manure or carrion.



GOLD BEETLE
Chrysina aurigans
F: Scarabaeidae

Found in Costa Rica and Panama, this beetle lives in deciduous forests, usually in rotting logs. The adults are nocturnal and attracted to light.

2–3.5 cm
¾–1⅜ in

» BEETLES

3 mm
⅛ in

ANT-LIKE BEETLE
Anthicus floralis
F: Anthicidae

Found across Europe and parts of Asia, this small beetle lives in and around decaying vegetation, manure, and compost heaps.

1–1.2 cm
⅜–½ in

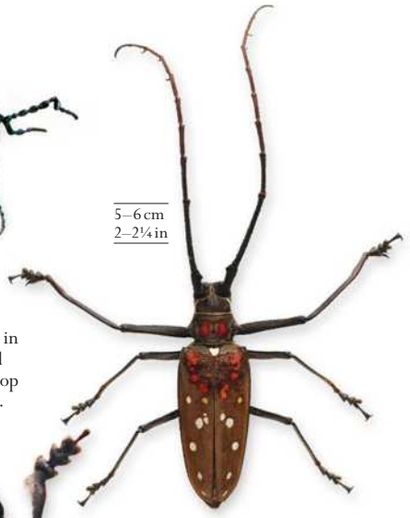
THICK-LEGGED FLOWER BEETLE
Oedemera nobilis
F: Oedemeridae

Often seen feeding on pollen at flowers in meadows, this beetle is native to S.W. Europe. Its larvae develop inside plant stems.

2.4–3.4 cm
1–1½ in

BLACK OIL BEETLE
Meloe proscarabaeus
F: Meloidae

This European beetle is found in warm meadows, heaths, and coastal areas. The larvae develop inside the nests of wild bees.



5–6 cm
2–2¼ in

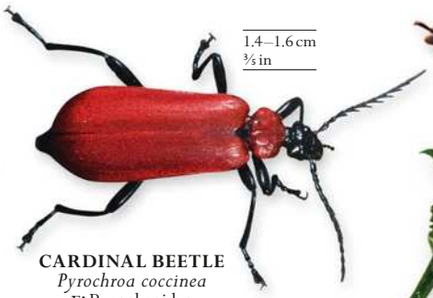
RED-SPOTTED LONGHORN BEETLE
Batocera rufomaculata
F: Cerambycidae

Also known as the mango borer or fig borer, this tropical species can be found throughout India and S.E. Asia.

1.8–2.2 cm
½–¾ in

GIBBIFER CALIFORNICUS
F: Erotylidae

This species is found in moist woodland in the S.W. USA. The larvae feed on fungi growing on trees and decaying wood.



1.4–1.6 cm
⅗ in

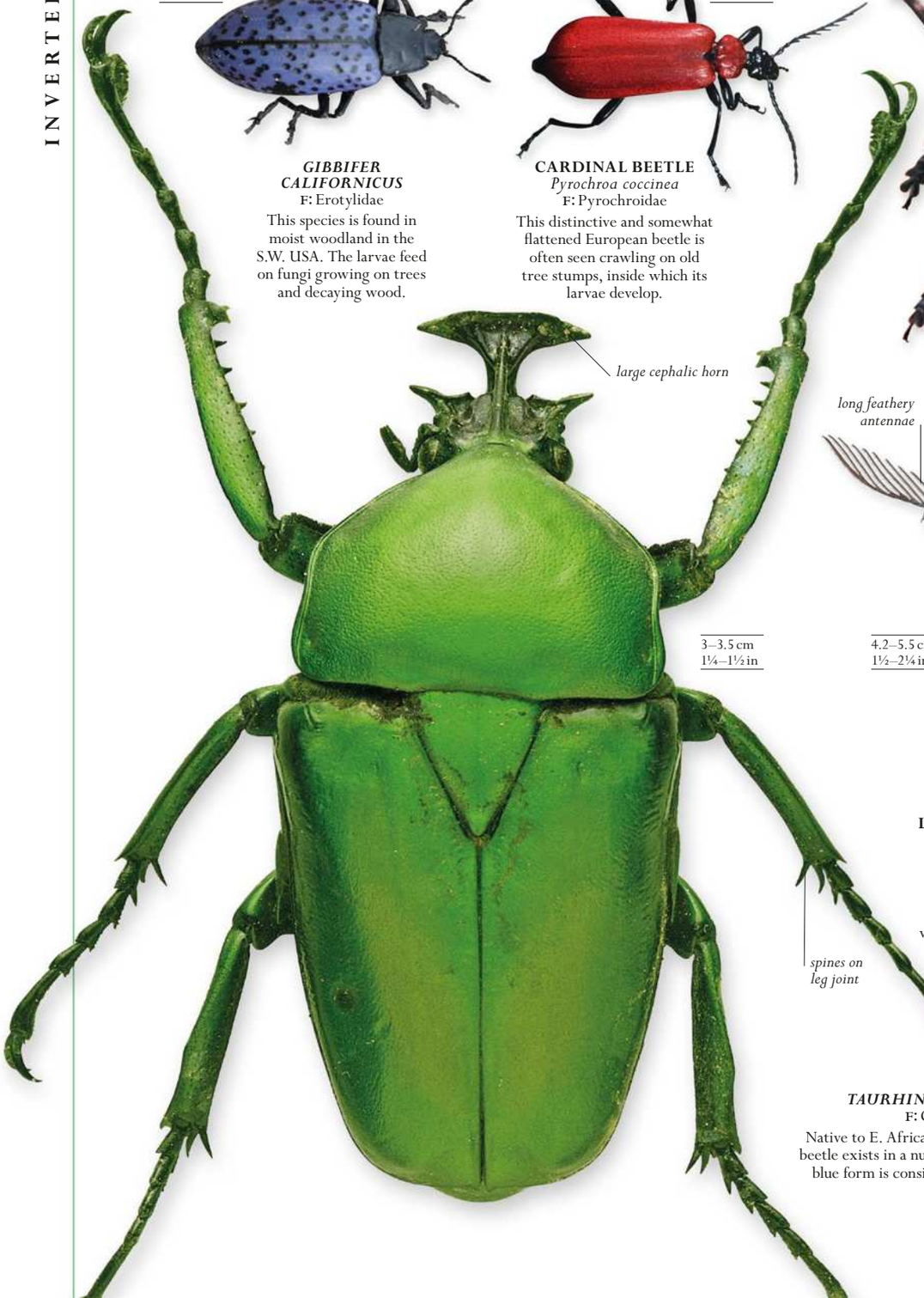
CARDINAL BEETLE
Pyrochroa coccinea
F: Pyrochroidae

This distinctive and somewhat flattened European beetle is often seen crawling on old tree stumps, inside which its larvae develop.

2.8–3.6 cm
1¼–1½ in

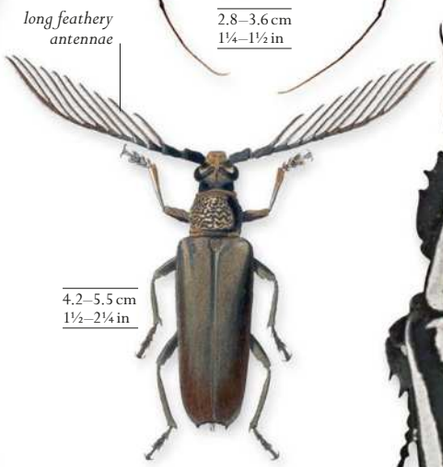
PHOSPHORUS VIRESCENS
F: Cerambycidae

Native to W. Africa, the larvae of this beetle burrow into some economically important species such as the cola tree.



TAURHINA POLYCHROUS
F: Cetoniidae

Native to E. Africa, especially Tanzania, this beetle exists in a number of colour forms. The blue form is considered to be a subspecies.



WALLACE'S LONGHORN BEETLE
Cyriopalus wallacei
F: Cerambycidae

This impressive beetle can be found in the rainforests of S.E. Asia, where its larvae bore into certain trees.

3.2–5 cm
1½–2 in

DICRONORHINA DERBYANA
F: Cetoniidae

This beetle is found in southern and eastern parts of Africa, where the larvae feed on decaying plant matter and animal dung.

JEWELLED FROG BEETLE
Sagra buqueti
F: Chrysomelidae
This beetle develops inside certain large-stemmed vines in S.E. Asia, particularly Thailand. Like many attractive tropical species, they are sold to collectors.

BLUE BANDED WEEVIL
Eupholus linnei
F: Curculionidae
Found on certain islands in E. Indonesia, this spectacular weevil, like many others in the genus *Eupholus*, feeds on yams.

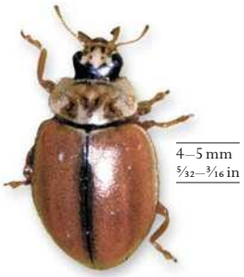
SCARLET LILY BEETLE
Lilioceris lilii
F: Chrysomelidae
Originally from Europe and Asia, this striking pest has spread to other parts of the world where lilies are grown.

BROAD BEAN WEEVIL
Bruchus rufimanus
F: Chrysomelidae
This species is a serious pest of broad bean crops. The adults feed on the pollen and their larvae tunnel into the seeds.

BAPTISIA WEEVIL
Trichapion rostrum
F: Brentidae
This small weevil feeds on the seeds of white and cream wild indigo (*Baptisia*) plants on the prairies of N. America.

CRATOSOMUS RODDAMI
F: Curculionidae
This species lives in C. and S. America. Its larvae are stem and bark borers of certain wild fruit trees.

EYED LADYBIRD
Anatis ocellata
F: Coccinellidae
This ladybird is native to Europe and is associated with coniferous trees, especially spruce and pine, where it feeds on aphids.

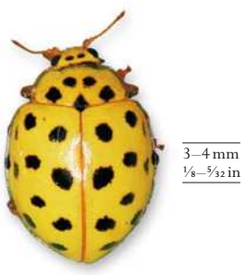


LARCH LADYBIRD
Aphidecta obliterata
F: Coccinellidae
This European species lives on conifers such as larch, fir, and pine, where it feeds on scale insects and conifer aphids.

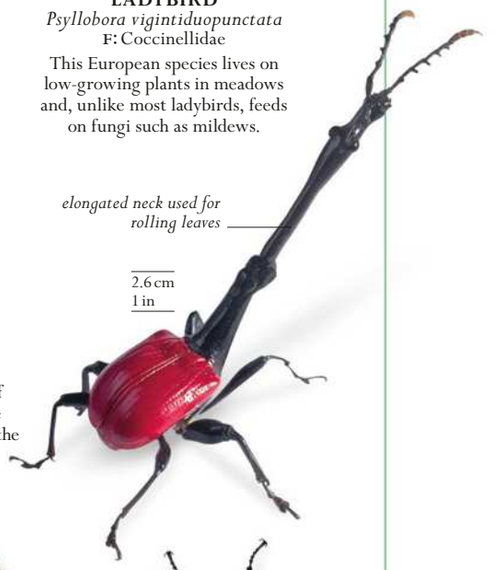
ONYMACRIS CANDIDIPENNIS
F: Tenebrionidae
Long legs and white wing cases help this diurnal beetle survive in the arid deserts along the southwestern coast of Africa.

BLACK VINE WEEVIL
Otiorhynchus sulcatus
F: Curculionidae
Widespread in Europe, N. America, and Australasia, this weevil is a serious pest of a wide range of garden and cultivated plants.

SEVEN-SPOT LADYBIRD
Coccinella septempunctata
F: Coccinellidae
This species is very common in a wide range of habitats right across Europe, and is now established in N. America.



TWENTY-TWO SPOT LADYBIRD
Psyllobora vigintiduopunctata
F: Coccinellidae
This European species lives on low-growing plants in meadows and, unlike most ladybirds, feeds on fungi such as mildews.

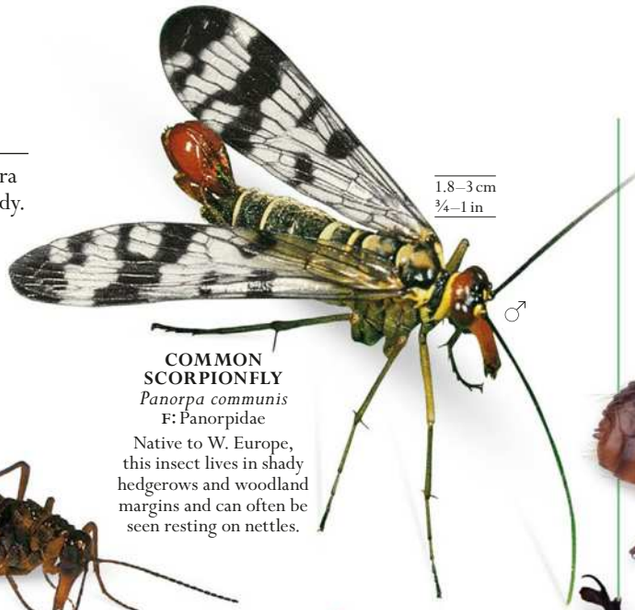


GIRAFFE-NECKED WEEVIL
Trachelophorus giraffa
F: Attelabidae
This beetle lives in the rainforests of Madagascar. It rolls the leaves of the *Dichaetanthera* tree with its neck, and the female lays her egg inside the roll.

CHURCHYARD BEETLE
Blaps mucronata
F: Tenebrionidae
This flightless, ground-living species is usually active after dark and can be found in dark and damp places, where it eats decaying matter.

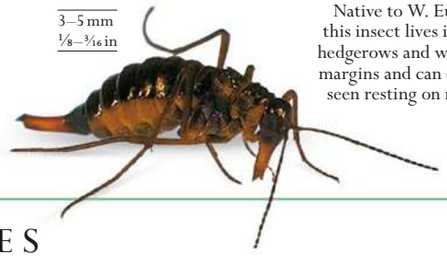
SCORPIONFLIES

These predatory insects of the order Mecoptera generally have an elongated and cylindrical body. The large, narrow wings may be clear or marked with spots or bands of dark colour. Some species are short-winged or completely wingless. The head, which has large eyes and thread-like antennae, is characteristically extended downwards in the form of a beak, at the end of which are biting mouthparts.



COMMON SCORPIONFLY
Panorpa communis
F: Panorpidae
Native to W. Europe, this insect lives in shady hedgerows and woodland margins and can often be seen resting on nettles.

SNOW SCORPIONFLY
Boreus hyemalis
F: Boreidae
The adult of this small, wingless European insect can only be seen in autumn and winter. It breeds among moss.



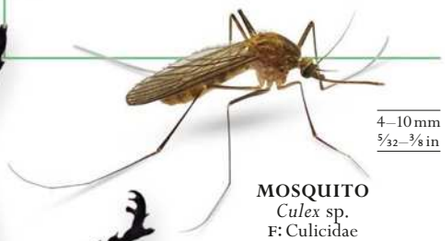
FLEAS

Members of the order Siphonaptera, fleas are laterally flattened, wingless, blood-sucking ectoparasites of mammals and some birds. Their head has short, piercing mouthparts and pairs of simple lateral eyes. The hind legs are highly specialized for jumping.

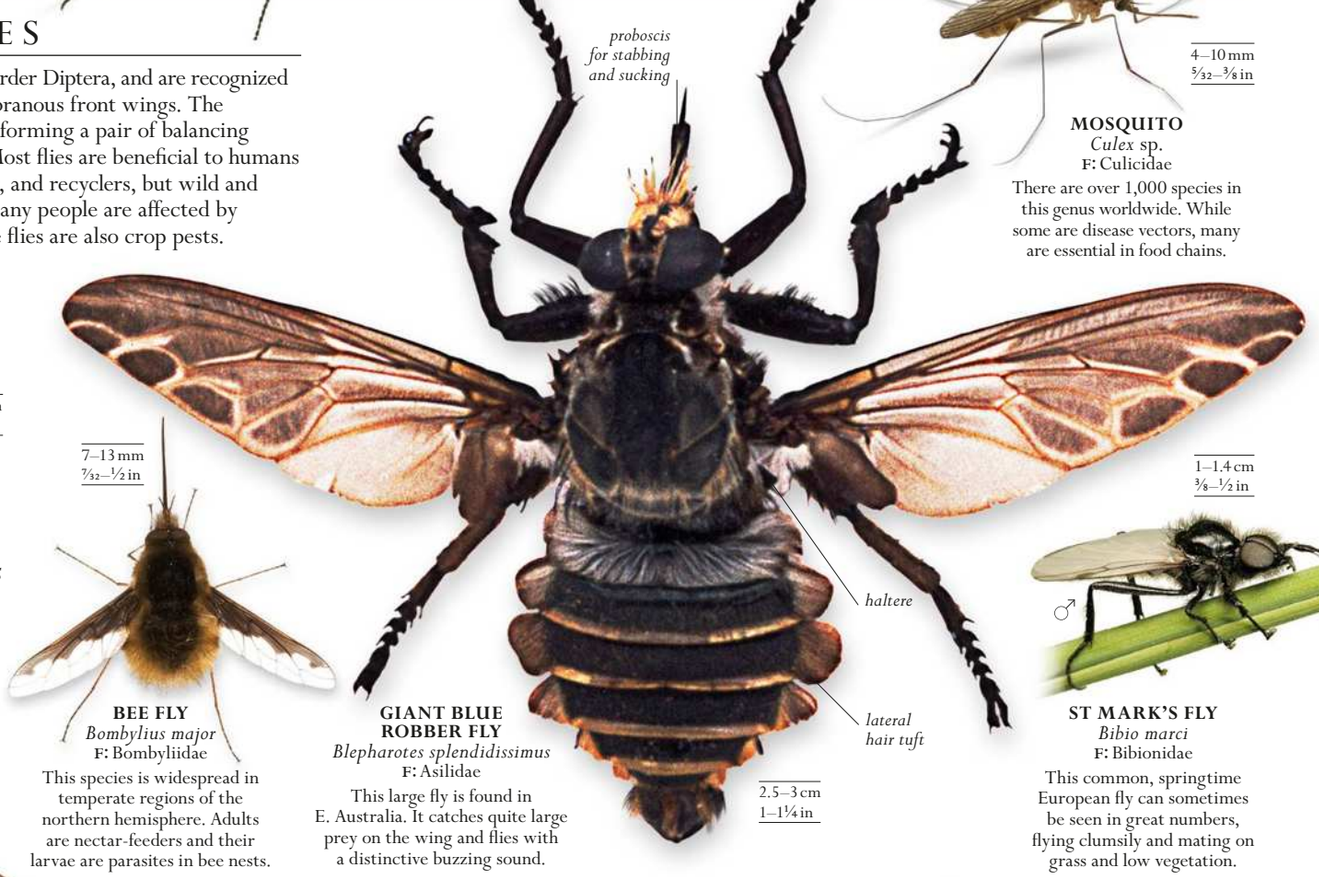
CAT FLEA
Ctenocephalides felis
F: Pulicidae
This species is very common worldwide. Also found on dogs, it can feed on the blood of several other animals, too – including humans.

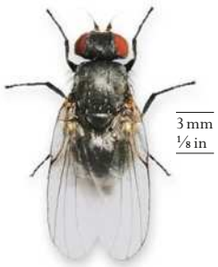
TRUE FLIES

True flies belong to the order Diptera, and are recognized by a single pair of membranous front wings. The hindwings are reduced, forming a pair of balancing organs called halteres. Most flies are beneficial to humans as pollinators, predators, and recyclers, but wild and domestic animals and many people are affected by fly-borne diseases. Some flies are also crop pests.



MOSQUITO
Culex sp.
F: Culicidae
There are over 1,000 species in this genus worldwide. While some are disease vectors, many are essential in food chains.





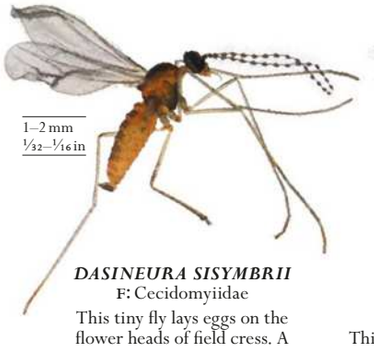
AGROMYZA RONDENSIS
F: Agromyzidae
This small fly can be found all over Europe. The larvae make leaf mines in a wide variety of grass species.

BEE FLY
Bombylius major
F: Bombyliidae
This species is widespread in temperate regions of the northern hemisphere. Adults are nectar-feeders and their larvae are parasites in bee nests.

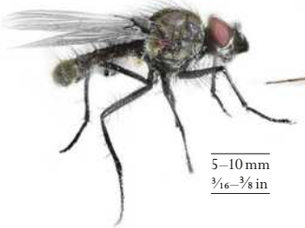
GIANT BLUE ROBBER FLY
Blepharotes splendidissimus
F: Asilidae
This large fly is found in E. Australia. It catches quite large prey on the wing and flies with a distinctive buzzing sound.

ST MARK'S FLY
Bibio marci
F: Bibionidae
This common, springtime European fly can sometimes be seen in great numbers, flying clumsily and mating on grass and low vegetation.

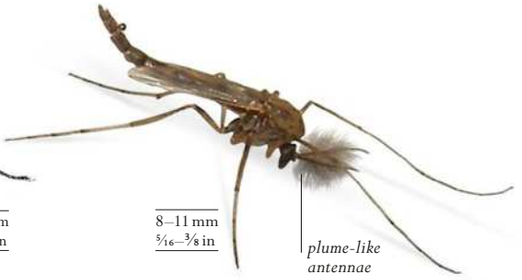
PLATYURA MARGINATA
F: Keroplatidae
Widespread throughout W. Europe, this fly lives in wooded areas. The larvae live inside rotting wood, where they eat other small insects.



DASINEURA SISYMBRII
F: Cecidomyiidae
This tiny fly lays eggs on the flower heads of field cress. A pale, spongy gall develops, inside which the larvae feed.



CABBAGE ROOT FLY
Delia radicum
F: Anthomyiidae
This small European fly can be a serious pest of wild and cultivated brassicas such as cabbage, turnip, and rape.



BUZZER MIDGE
Chironomus plumosus
F: Chironomidae
This fly is found all across the northern hemisphere. The larvae are called bloodworms and live in muddy-bottomed ponds.

HOUSE FLY
Musca domestica
F: Muscidae

This species is found worldwide and is the most common fly around dwellings, where it transmits a number of disease-causing organisms to foodstuffs.

GRASS FLY
Meromyza pratorum
F: Chloropidae

This fly occurs across the northern hemisphere, especially in sandy coastal regions. The larvae burrow in stems of marram grass and reed grass.

POECILOBOTHRUS NOBILITATUS
F: Dolichopodidae

This European species can be found in damp habitats near water. Males display in sunny patches by waving their wings.

LESSER HOUSE FLY
Fannia canicularis
F: Fanniidae

Able to breed in almost any decaying, semi-liquid matter, this species is particularly associated with human habitation.

MOTH FLY
Clogmia albipunctata
F: Psychodidae

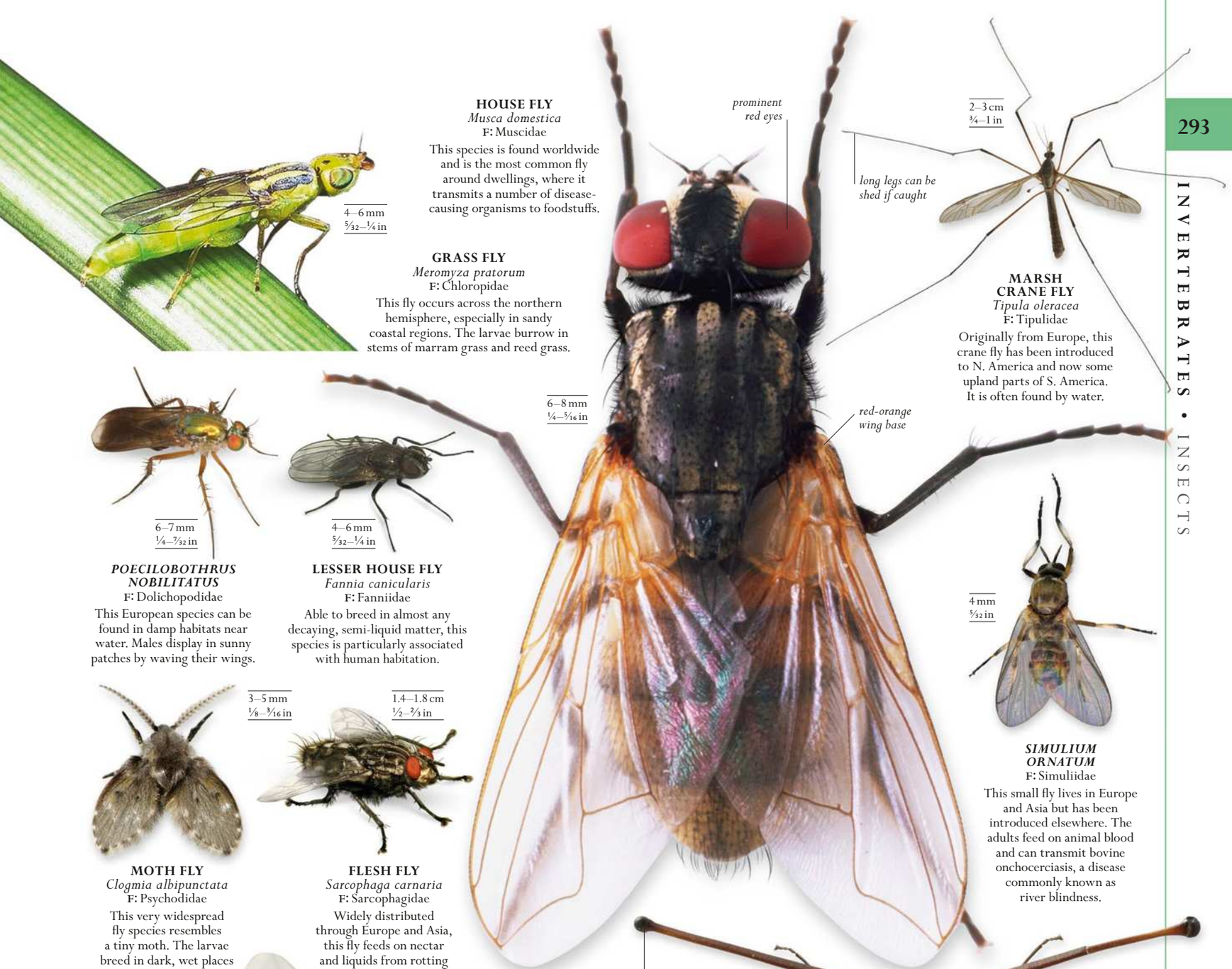
This very widespread fly species resembles a tiny moth. The larvae breed in dark, wet places such as drains, tree holes, and sewage.

FLESH FLY
Sarcophaga carnaria
F: Sarcophagidae

Widely distributed through Europe and Asia, this fly feeds on nectar and liquids from rotting matter. The female lays small larvae on carrion.

FERRUGINOUS BEE-GRABBER
Sicus ferrugineus
F: Conopidae

This European fly lays eggs in the abdomen of certain bumble bees. The larvae develop as internal parasites, killing the host.



MARSH CRANE FLY
Tipula oleracea
F: Tipulidae

Originally from Europe, this crane fly has been introduced to N. America and now some upland parts of S. America. It is often found by water.

SIMULIUM ORNATUM
F: Simuliidae

This small fly lives in Europe and Asia but has been introduced elsewhere. The adults feed on animal blood and can transmit bovine onchocerciasis, a disease commonly known as river blindness.

ROTHSCHILD'S ACHIAS
Achias rothschildi
F: Platystomatidae

Males of this Papua New Guinean fly have very elongate eyestalks, which are used in territorial and mating displays.

FARMYARD MIDGE
Culicoides nubeculosus
F: Ceratopogonidae

This widespread European fly breeds in mud contaminated by dung or sewage. Adults suck the blood of horses and cattle.

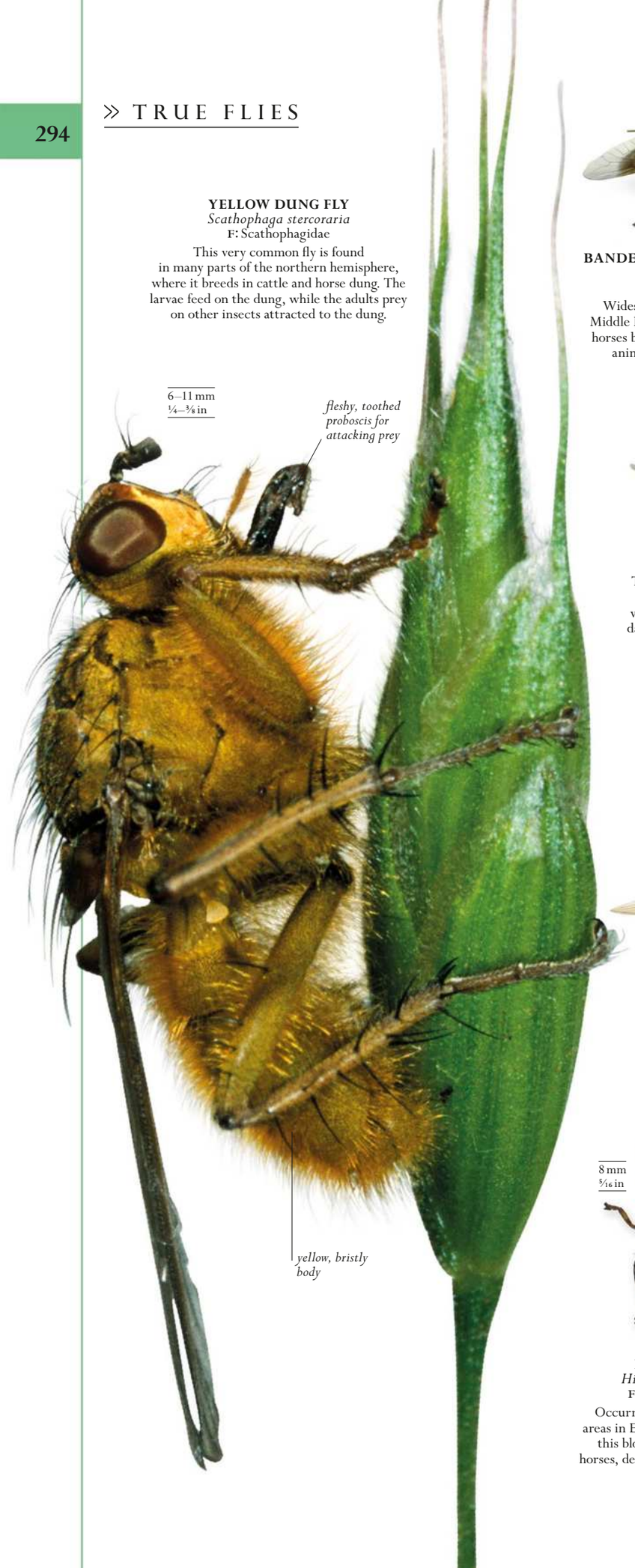
BLUEBOTTLE
Calliphora vicina
F: Calliphoridae

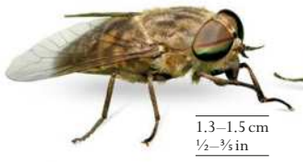
Found in Europe and N. America, this species is especially common in urban areas and breeds in dead pigeons and rodents.

»

YELLOW DUNG FLY
Scathophaga stercoraria
F: Scathophagidae

This very common fly is found in many parts of the northern hemisphere, where it breeds in cattle and horse dung. The larvae feed on the dung, while the adults prey on other insects attracted to the dung.





BANDED BROWN HORSE FLY
Tabanus bromius
F: Tabanidae

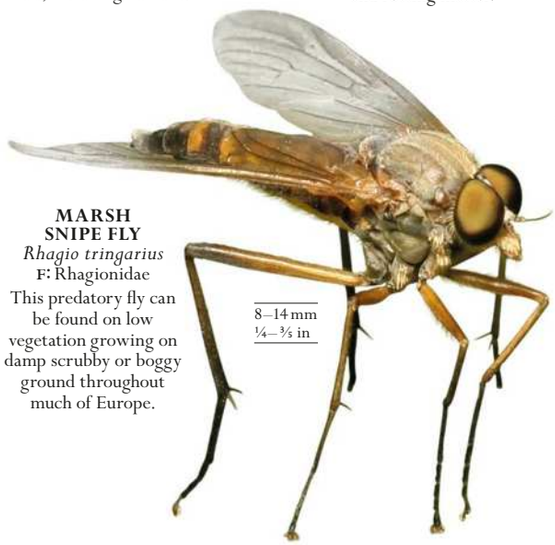
Widespread in Europe and the Middle East, this fly mainly attacks horses but will feed on some other animals, including humans.

***SEPSIS* SP.**
F: Sepsidae

These flies are common and widespread in a wide variety of habitats. The larvae develop in animal dung and rotting matter.

COMMON FRUIT FLY
Drosophila melanogaster
F: Drosophilidae

A common laboratory animal, this widespread species has a distinctive dark patch on the abdomen and breeds in rotting fruits.



MARSH SNIPE FLY
Rhagio tringarius
F: Rhagionidae

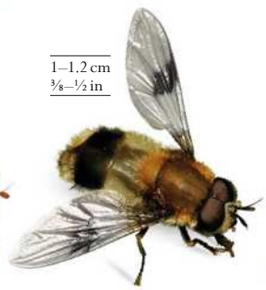
This predatory fly can be found on low vegetation growing on damp scrubby or boggy ground throughout much of Europe.

SYRPHUS RIBESII
F: Syrphidae

The larvae of this nectar-feeding fly are major predators of aphids in the northern hemisphere. Its coloration mimics that of wasps and bees to deter predators.

MARMALADE HOVER FLY
Episyrphus balteatus
F: Syrphidae

Very common in a variety of habitats including gardens, this European fly feeds on pollen and nectar. The larvae eat aphids.



LEUCOZONA LEUCORUM
F: Syrphidae

This northern hemisphere species can be found visiting flowers in damp woodlands in the spring and early summer. Its larvae prey on aphids.

DRONE FLY
Eristalis tenax
F: Syrphidae

This European fly, which has been introduced to N. America, is a good mimic of the honey bee. The larvae breed in stagnant water.

FOREST FLY
Hippobosca equina
F: Hippoboscidae

Occurring mainly in wooded areas in Europe and parts of Asia, this bloodsucking fly attacks horses, deer, and sometimes cattle.

PENICILLIDIA FULVIDA
F: Nycteribiidae

Widespread in sub-Saharan Africa, this bloodsucking, wingless, ectoparasitic fly can be found on a wide range of bat species.

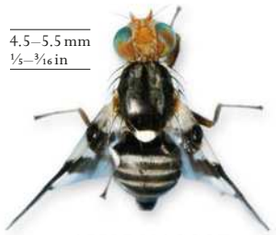
GAUROMYDAS HEROS
F: Mydidae

This S. American insect, the world's largest fly, breeds inside the nests of leaf-cutter ants, where the young are thought to eat scarab beetle larvae.

2.4–3 cm
1–1¼ in

RODENT BOT FLY
Cuterebra fontinella
F: Oestridae

This parasitic fly lives in N. America. The larvae develop inside the bodies of rodents such as white-footed mice.



4.5–5.5 mm
⅛–3⁄16 in

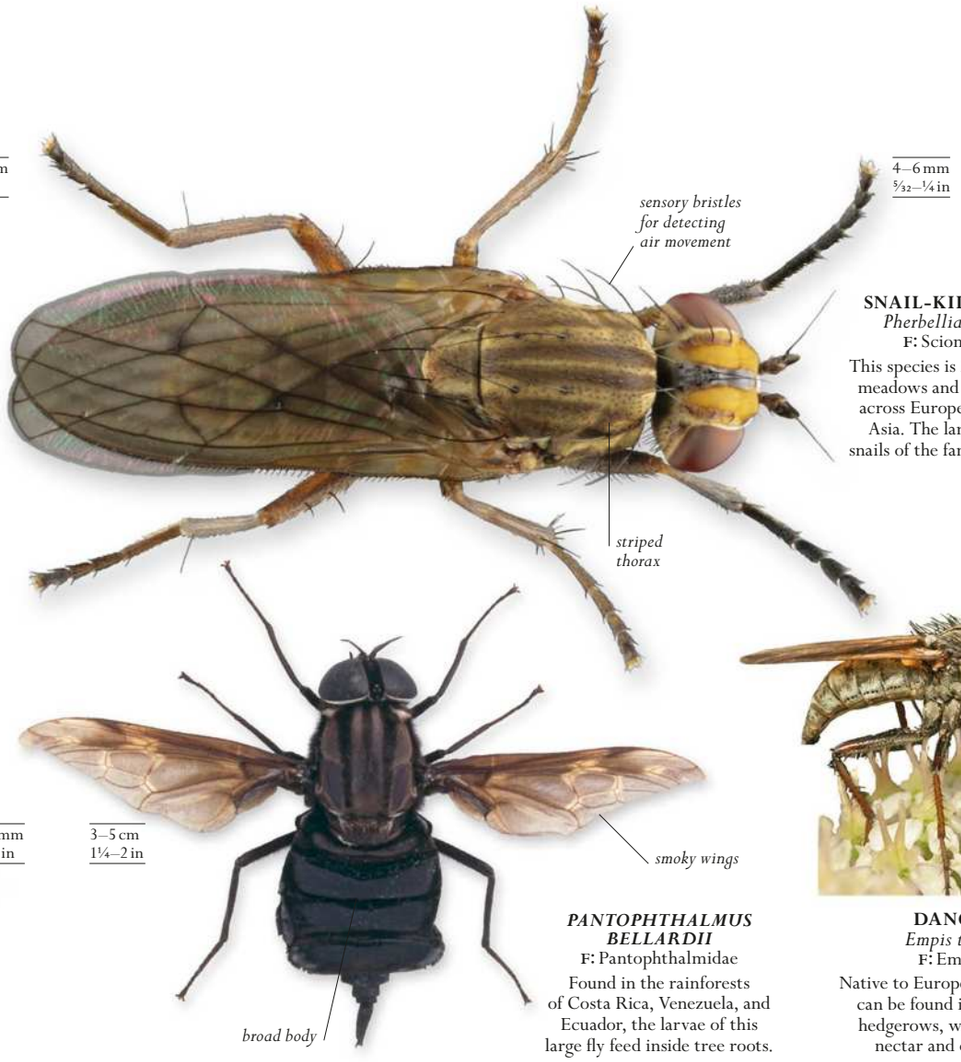
APPLE MAGGOT
Rhagoletis pomonella
F: Tephritidae

Native to N. America, this fly is an apple pest but also attacks hawthorn, plums, cherries, and other related fruit trees.

8–15 mm
¼–⅗ in

SAVANNAH TSETSE FLY
Glossina morsitans
F: Glossinidae

Confined to parts of Africa, this fly is one of the species that transmits the trypanosome parasite that causes sleeping sickness in humans.



4–6 mm
5⁄32–¼ in

SNAIL-KILLING FLY
Pherbellia cinerella
F: Sciomyzidae

This species is found in damp meadows and marshy areas across Europe and parts of Asia. The larvae prey on snails of the family Helicidae.

3–5 cm
1¼–2 in

PANTOPHTHALMUS BELLARDII
F: Pantophthalmidae

Found in the rainforests of Costa Rica, Venezuela, and Ecuador, the larvae of this large fly feed inside tree roots.

1–1.2 cm
⅜–½ in

DANCE FLY
Empis tessellata
F: Empididae

Native to Europe and Asia, this fly can be found in meadows and hedgerows, where it feeds on nectar and other insects.

CADDISFLIES

Closely related to the Lepidoptera, these slender, rather moth-like insects of the order Trichoptera are covered with hairs, not scales. The head has long, thread-like antennae and weakly developed mouthparts. The two pairs of wings are held tent-like over the body at rest. Caddisfly larvae are aquatic and often construct species-specific portable shelters out of small stones or plant fragments.

3–4.5 mm
⅛–⅕ in

SALT AND PEPPER MICROCADDIS
Agraylea multipunctata
F: Hydroptilidae

This small caddisfly is widespread and common in N. America. It has narrow wings and breeds in algae-rich ponds and lakes.

2.8–3.2 cm
1⅛–1¼ in

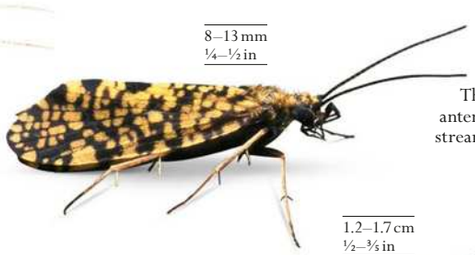
GREAT RED SEDGE
Phryganea grandis
F: Phryganeidae

This European caddisfly breeds in weedy lakes and slow rivers. The larvae make a case from cut leaf sections arranged in a spiral.

1.2–1.5 cm
½–⅗ in

MARBLED SEDGE
Hydropsyche contubernalis
F: Hydropsychidae

This caddisfly flies in the evening and breeds in rivers and streams. The aquatic larvae weave a net to catch food.



8–13 mm
¼–½ in

DARK-SPOTTED SEDGE
Philopotamus montanus
F: Philopotamidae

This European caddisfly has shortish antennae and breeds in fast-flowing rocky streams. The larvae make tube-like nets on the undersides of rocks.

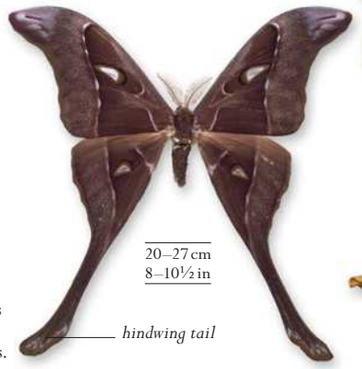
1.2–1.7 cm
½–⅗ in

MOTTLED SEDGE
Glyphotaelius pellucidus
F: Limnephilidae

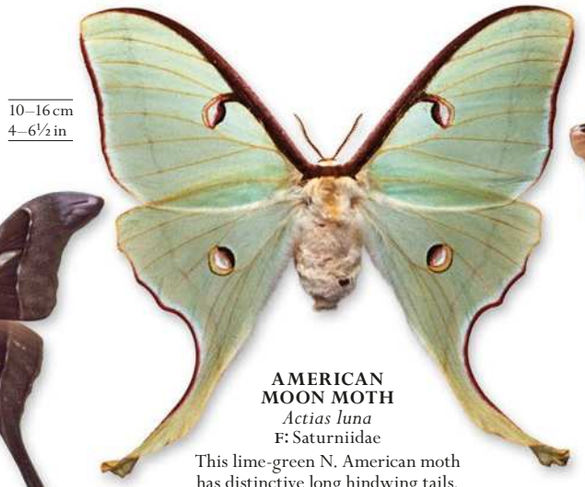
This European caddisfly breeds in lakes and small ponds. The larvae make a case out of fragments of withered tree leaves.

MOTHS AND BUTTERFLIES

Members of the order Lepidoptera are covered with minute scales. They have large compound eyes and a feeding tube called a proboscis. Larvae, known as caterpillars, pupate, metamorphosing into their adult form. Most moths are nocturnal and rest with their wings open; the majority of butterflies are diurnal and rest with their wings closed.



HERCULES MOTH
Coscinocera hercules
F: Saturniidae
Found in New Guinea and Australia, this moth is one of the biggest in the world. Only the male has the long hindwing tails.



AMERICAN MOON MOTH
Actias luna
F: Saturniidae
This lime-green N. American moth has distinctive long hindwing tails. The caterpillars feed on a range of deciduous trees.

POLYPHEMUS MOTH
Antheraea polyphemus
F: Saturniidae
Common and widespread in the USA and S. Canada, this moth has large eyespots on the wings, to startle predators.

GIANT LEOPARD MOTH
Hypercompe scribonia
F: Erebidae
The distribution of this striking moth extends from S.E. Canada as far south as Mexico. The caterpillars feed on a variety of plants.

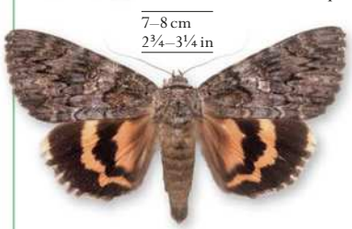
OAK EGGAR
Lasiocampa quercus
F: Lasiocampidae
Ranging from Europe to N. Africa, the caterpillars of this moth feed on the foliage of bramble, oak, heather, and other plants.

LAPPET MOTH
Gastropacha quercifolia
F: Lasiocampidae
Found in Europe and Asia, the specific name of this large moth refers to its resting appearance, which resembles a cluster of dead oak leaves.

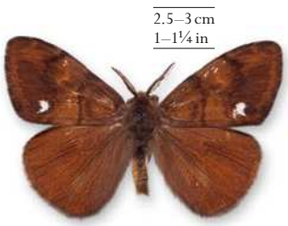
PINE-TREE LAPPET
Dendrolimus pini
F: Lasiocampidae
This moth is widespread in coniferous forests across Europe and Asia, where the caterpillars feed on pine, spruce, and fir.

AUSTRALIAN MAGPIE MOTH
Nyctemera amicus
F: Erebidae
Widespread in Australia and also found in New Zealand, the caterpillars of this day-flying moth feed on plants such as groundsel and ragwort.

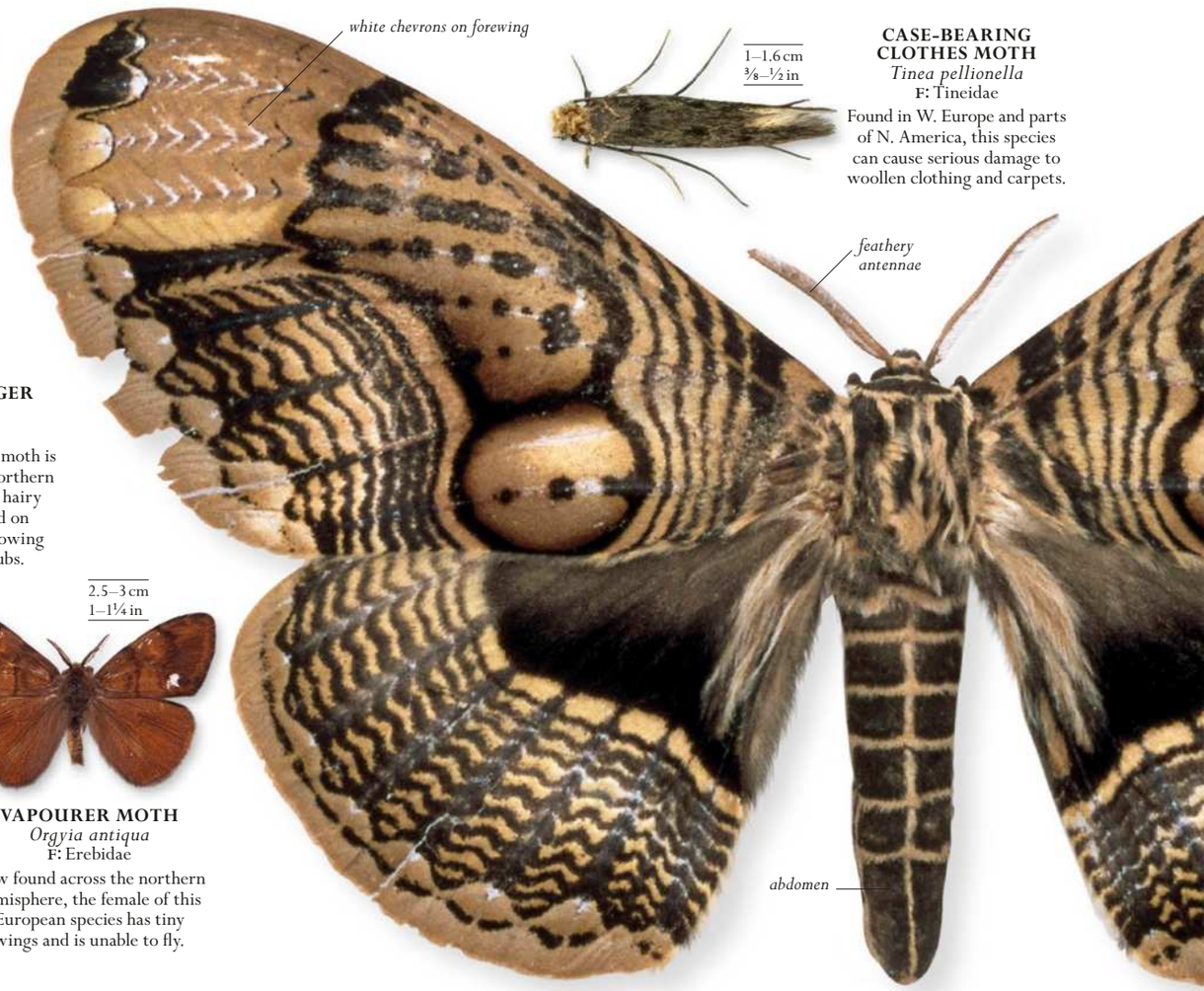
GARDEN TIGER
Arctia caja
F: Erebidae
This unmistakable moth is found across the northern hemisphere. The hairy caterpillars feed on a range of low-growing plants and shrubs.



ILIA UNDERWING
Catocala ilia
F: Erebidae
This widespread species from N. America has distinctive red-banded hindwings. The caterpillars feed on the foliage of oak trees.



VAPOURER MOTH
Orgyia antiqua
F: Erebidae
Now found across the northern hemisphere, the female of this European species has tiny wings and is unable to fly.



CASE-BEARING CLOTHES MOTH
Tinea pellionella
F: Tineidae
Found in W. Europe and parts of N. America, this species can cause serious damage to woollen clothing and carpets.

24–30 cm
9½–12 in

GIANT AGRIPPA
Thysania agrippina
F: Noctuidae

Found in C. and parts of S. America, this species has one of the largest wingspans of any moth in the world.

6.5–9.5 cm
2½–3¾ in

DIVA MOTH
Divana diva
F: Castniidae

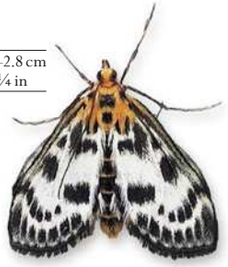
Found in tropical forests in S. America, this day-flying species is well camouflaged at rest despite its brightly coloured hindwings.

SNOUT MOTH
Vitessa suradeva
F: Pyralidae

This moth occurs in India, parts of S.E. Asia, and New Guinea. The caterpillars feed in a web on young leaves of poisonous shrubs.

4–5 cm
1½–2 in

2.4–2.8 cm
1–1¼ in



SMALL MAGPIE
Anania hortulata
F: Pyralidae

Found in hedgerows and waste ground, the caterpillars of this very common European species feed on rolled nettle leaves.

6–10 cm
2¼–4 in

SILVER-SPOTTED GHOST MOTH
Sthenopis argenteomaculatus
F: Hepialidae

This species occurs in S. Canada and parts of the USA. The caterpillars mainly feed inside the roots of alder trees.

ACACIA CARPENTER MOTH
Endoxyla encalypti
F: Cossidae

The robust, white caterpillars of this large and distinctive Australian moth burrow into the woody tissue of certain species of the acacia tree.

9–12 cm
3½–4¾ in

large eyespot to scare predators

wavy pattern of black and orange lines

10–16 cm
4–6½ in

WALLICH'S OWL MOTH
Brahmaea wallichii
F: Brahmaeidae

This large moth occurs from N. India to China and Japan. The caterpillars eat the foliage of ash, privet, and lilac.

5–6.5 cm
2–2½ in

LARGE EMERALD
Geometra papilionaria
F: Geometridae

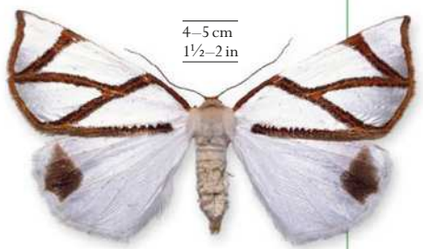
This moth occurs across Europe and the temperate parts of Asia. The caterpillars feed mainly on the foliage of birch trees.

3–4 cm
1¼–1½ in

ARGENT AND SABLE
Rheumaptera hastata
F: Geometridae

The common name for this day-flying moth from the northern hemisphere comes from the heraldic terms for silvery-white and black.

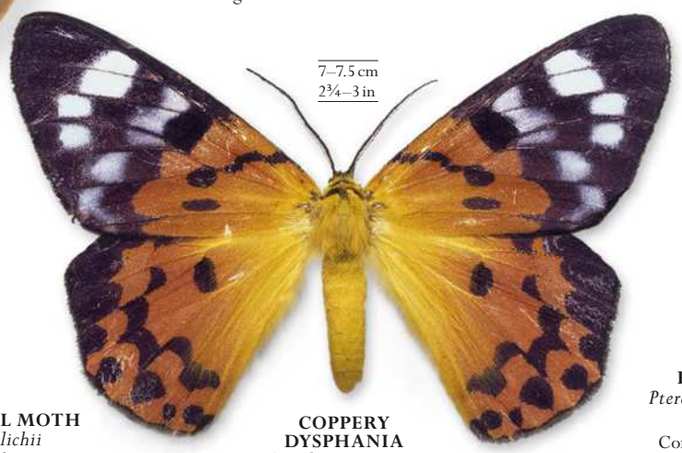
4–5 cm
1½–2 in



CLARA'S SATIN MOTH
Thalaina clara
F: Geometridae

The caterpillars of this moth, which occurs in E. and S.E. Australia and N. Tasmania, feed on acacia foliage.

7–7.5 cm
2¾–3 in



COPPERY DYSPHANIA
Dysphania cuprina
F: Geometridae

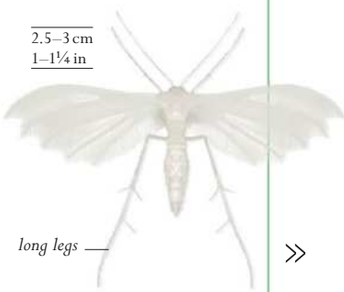
Widespread across S.E. Asia, this brightly coloured moth flies during the day and is thought to be unpalatable to birds.

4–6 cm
1½–2¼ in

SILK MOTH
Bombyx mori
F: Bombycidae

Originating in China, the silk moth has been bred in captivity, on a diet of white mulberry leaves, for thousands of years. Its cocoon is used to make silk.

2.5–3 cm
1–1¼ in



long legs

WHITE PLUME-MOTH
Pterophorus pentadactyla
F: Pterophoridae

Common across Europe on dry grassland, waste ground, and gardens, the caterpillars of this distinctive species feed on hedge bindweed.

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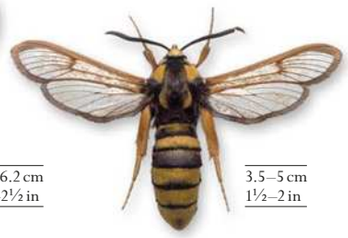
REGENT SKIPPER
Euschemon rafflesia
F: Hesperiidae

This brightly coloured species is native to tropical and subtropical forests in E. Australia, where it can be seen feeding at flowers.

GUAVA SKIPPER
Phocides polybius
F: Hesperiidae

This species can be found from S. Texas to as far south as Argentina. The caterpillars feed inside rolled-up guava leaves.

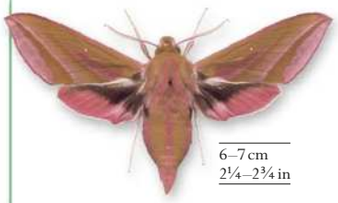


HORNET MOTH
Sesia apiformis
F: Sesiidae

To deter predators, the adults of this moth look very similar to hornets but are harmless. The caterpillars bore into the trunk and roots of poplars and willows in Europe and the Middle East.

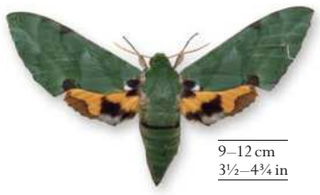
BUFF-TIP
Phalera bucephala
F: Notodontidae

This moth is found in Europe and eastwards to Siberia. At rest its folded wings wrap around its body for camouflage, closely resembling a broken-off twig.



ELEPHANT HAWK MOTH
Deilephila elpenor
F: Sphingidae

This pretty, pinkish hawk moth is widespread in the temperate parts of Europe and Asia. The caterpillars feed on bedstraw and willowherb.

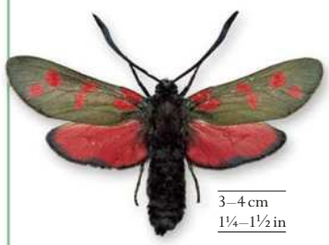


VERDANT SPHINX
Euchloron megaera
F: Sphingidae

This distinctive moth is widespread throughout sub-Saharan Africa. The caterpillars feed on the foliage of creepers of the grape family.

COMMON MORPHO
Morpho peleides
F: Nymphalidae

This butterfly is widespread in tropical forests in C. and S. America. The adults feed on the juices of rotting fruits.

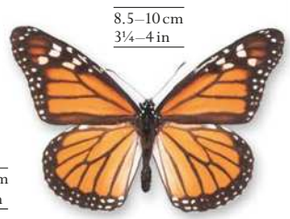


SIX-SPOT BURNET
Zygaena filipendulae
F: Zygaenidae

Brightly coloured and distasteful to birds, this day-flying moth can be found in meadows and woodland clearings across Europe.

LITTLE WOOD SATYR
Euptychia cymela
F: Nymphalidae

This woodland butterfly is found from S. Canada to N. Mexico. The caterpillars feed on grasses in clearings close to water.

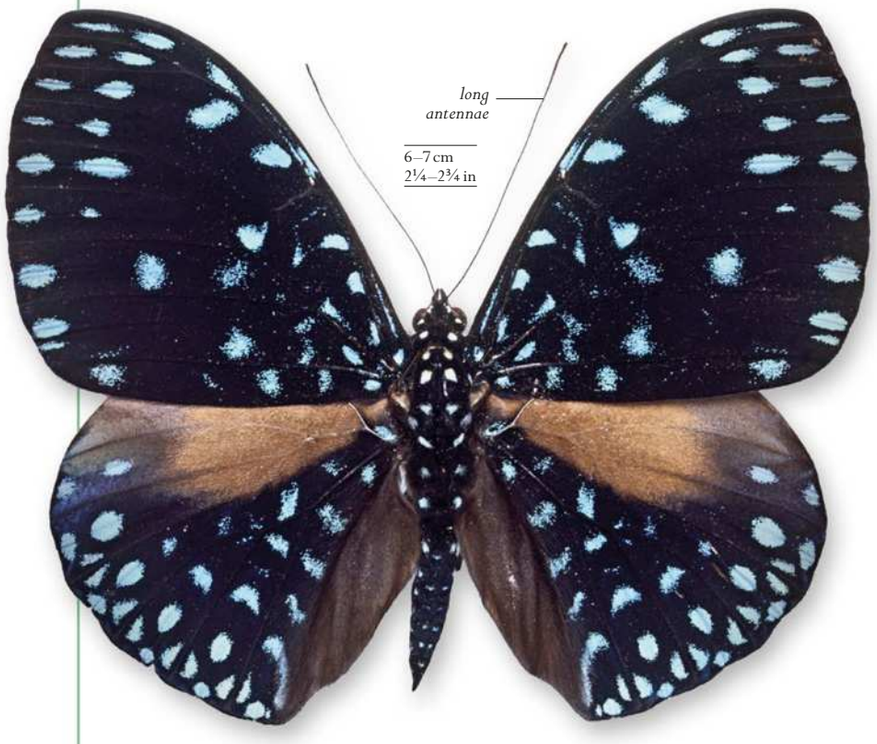


MONARCH BUTTERFLY
Danaus plexippus
F: Nymphalidae

A well-known migrant, this butterfly has spread from the Americas to many other parts of the world. The caterpillars feed on the milkweed plant.

WHITE ADMIRAL
Ladoga camilla
F: Nymphalidae

This butterfly can be found across temperate Europe and Asia to Japan. The caterpillars feed on the foliage of the honeysuckle.



QUEEN CRACKER
Hamadryas arethusa
F: Nymphalidae

The common name for this butterfly, found in forests from Mexico to Bolivia, refers to the clicking noise it makes when it flies.

PURPLE EMPEROR
Apatura iris
F: Nymphalidae

Found in dense oak woodland throughout Europe and Asia as far east as Japan, the male of this butterfly is iridescent purple whereas the female is dull brown.

INDIAN LEAF BUTTERFLY
Kallima inachus
F: Nymphalidae

With undersides that resemble a brown leaf, this butterfly is perfectly camouflaged at rest with its wings folded. It occurs from India to S. China.

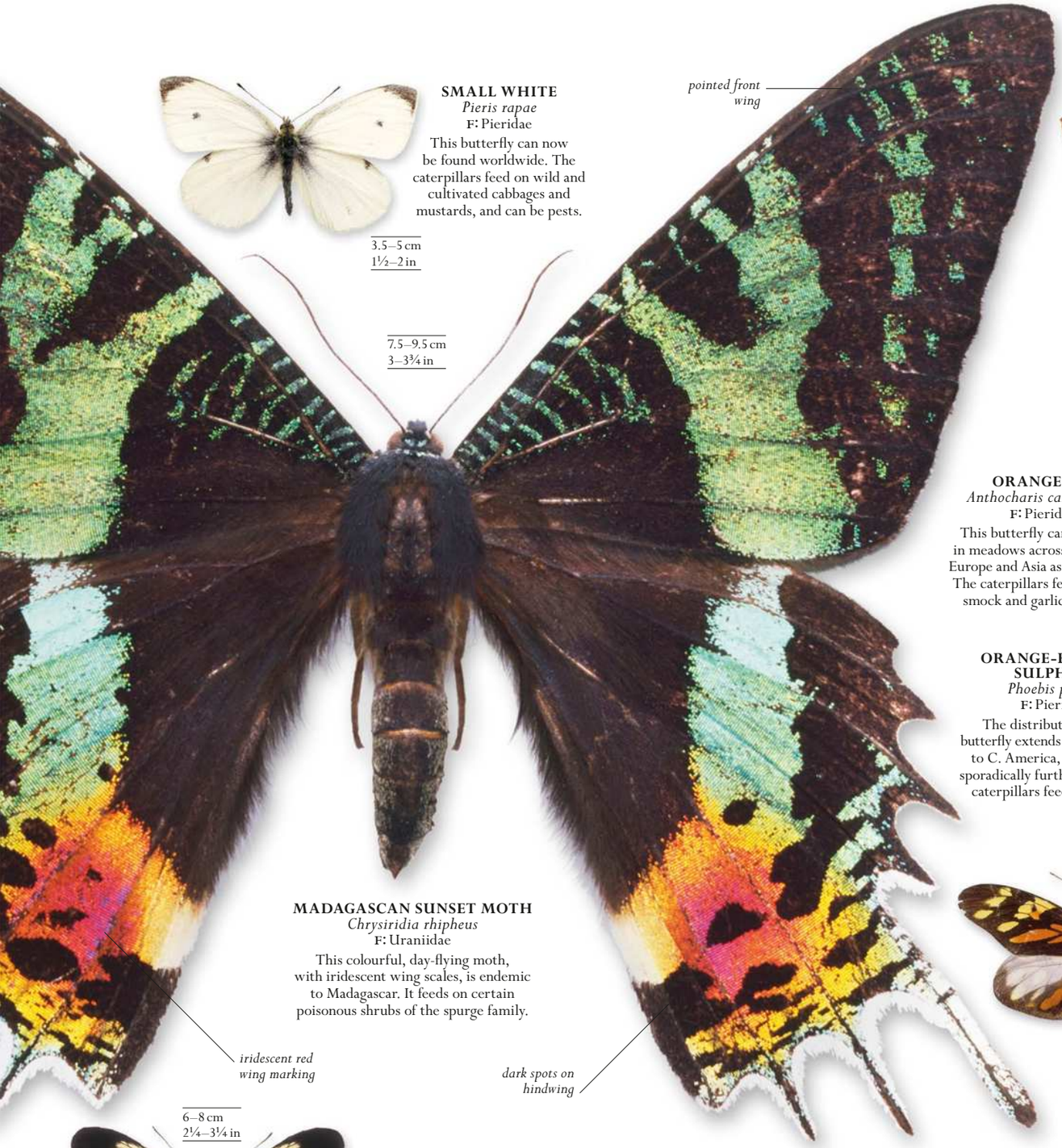
SMALL WHITE
Pieris rapae
F: Pieridae

This butterfly can now be found worldwide. The caterpillars feed on wild and cultivated cabbages and mustards, and can be pests.

3.5–5 cm
1½–2 in

pointed front wing

7.5–9.5 cm
3–3¾ in



iridescent red wing marking

dark spots on hindwing

MADAGASCAN SUNSET MOTH
Chrysiridia rhipheus
F: Uraniidae

This colourful, day-flying moth, with iridescent wing scales, is endemic to Madagascar. It feeds on certain poisonous shrubs of the spurge family.

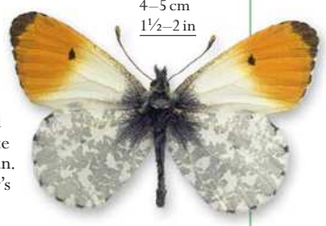
4–6.5 cm
1½–2½ in

♂

CALIFORNIA DOG-FACE
Zerene eurydice
F: Pieridae

This butterfly is restricted to parts of California and, sometimes, western Arizona. It breeds on a shrub called Napa False Indigo.

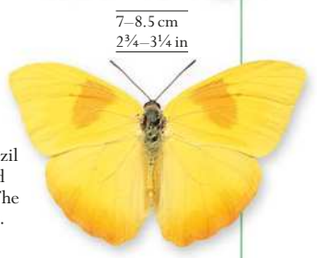
4–5 cm
1½–2 in



ORANGE TIP
Anthocharis cardamines
F: Pieridae

This butterfly can be found in meadows across temperate Europe and Asia as far as Japan. The caterpillars feed on lady's smock and garlic mustard.

7–8.5 cm
2¾–3¼ in



ORANGE-BARRED SULPHUR
Phoebis philea
F: Pieridae

The distribution of this butterfly extends from S. Brazil to C. America, S. USA, and sporadically further north. The caterpillars feed on sennas.

5–7 cm
2–2¾ in

TIGER PIERID
Dismorphia amphione
F: Pieridae

This colourful butterfly, which mimics unpalatable butterfly species for protection from predators, is widespread and common from Mexico southwards to S. America.

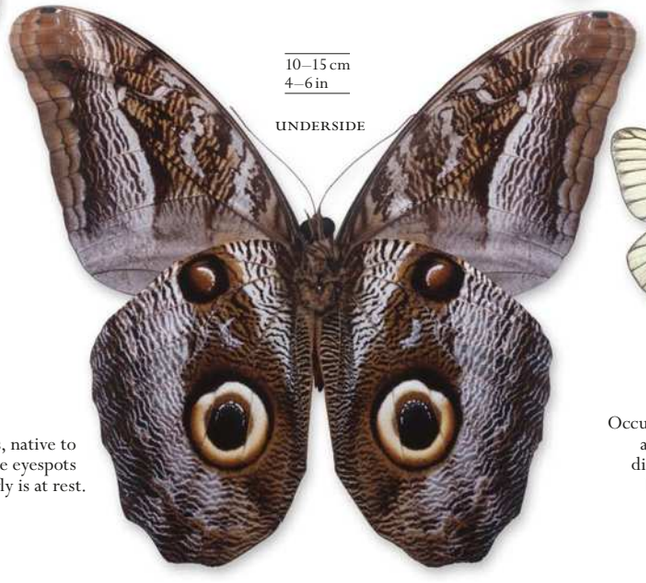
6–8 cm
2¼–3¼ in

SMALL POSTMAN
Heliconius erato
F: Nymphalidae

This butterfly is common along forest edges and open ground from C. America to S. Brazil. The caterpillars eat passionflower foliage.

10–15 cm
4–6 in

UNDERSIDE



OWL BUTTERFLY
Caligo idomeneus
F: Nymphalidae

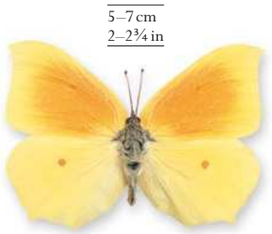
The underside of this large species, native to S. America, has prominent owl-like eyespots to deter predators when the butterfly is at rest.

5.5–7.5 cm
2¼–3 in

BLACK-VEINED WHITE
Aporia crataegi
F: Pieridae

Occurring across Europe, N. Africa, and Asia as far as Japan, this distinctive butterfly breeds on hawthorn and blackthorn.

5–7 cm
2–2¾ in



CLEOPATRA
Gonepteryx cleopatra
F: Pieridae

This butterfly is common in countries around the Mediterranean, particularly in lightly wooded coastal areas and scrubland. The caterpillars feed on species of buckthorn.

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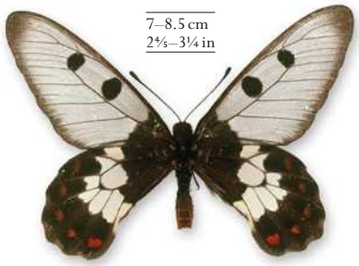


7–8.5 cm
2⅘–3¼ in

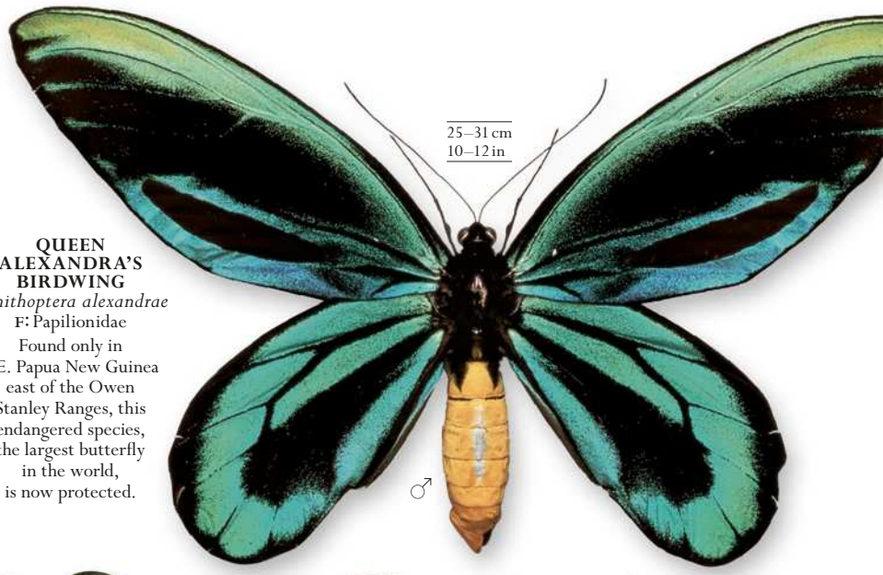
BIG GREASY BUTTERFLY
Cressida cressida
F: Papilionidae

This species is found in grassland and drier forests in Australia and Papua New Guinea, where its pipevine foodplants grow.

6–10 cm
2¼–4 in

ZEBRA SWALLOWTAIL
Photographium marcellus
F: Papilionidae

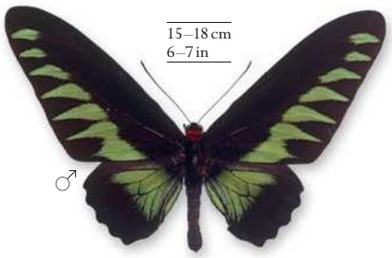
Found in damp woodlands in eastern N. America, this butterfly has distinctive black and white markings. The caterpillars feed on pawpaw.



25–31 cm
10–12 in

QUEEN ALEXANDRA'S BIRDWING
Ornithoptera alexandrae
F: Papilionidae

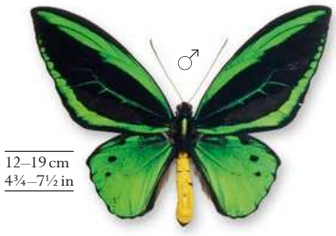
Found only in S.E. Papua New Guinea east of the Owen Stanley Ranges, this endangered species, the largest butterfly in the world, is now protected.



15–18 cm
6–7 in

RAJAH BROOKE'S BIRDWING
Troides brookiana
F: Papilionidae

This butterfly lives in the tropical forests of Borneo and Malaysia, where the adults sip fruit juices and nectar. The caterpillars feed on pipevines.



12–19 cm
4¾–7½ in

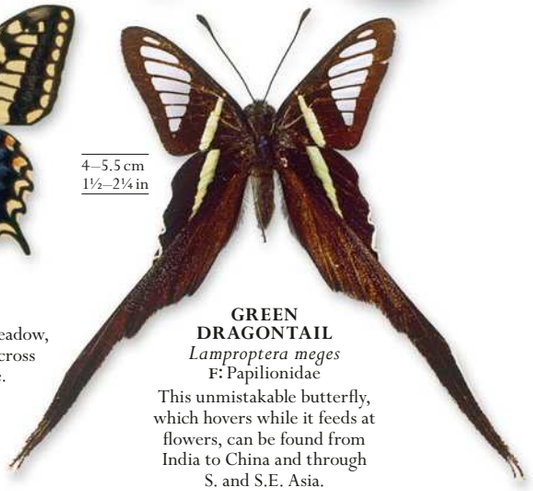
COMMON GREEN BIRDWING
Ornithoptera priamus
F: Papilionidae

This large butterfly occurs from Papua New Guinea and the Solomon Islands to tropical N. Australia. The caterpillars eat pipevines.

7.5–9 cm
3–3½ in

SWALLOWTAIL
Papilio machaon
F: Papilionidae

This species is found in wet meadow, fenland, and other habitats across the northern hemisphere. The caterpillars feed on various umbellifers.



4–5.5 cm
1½–2¼ in

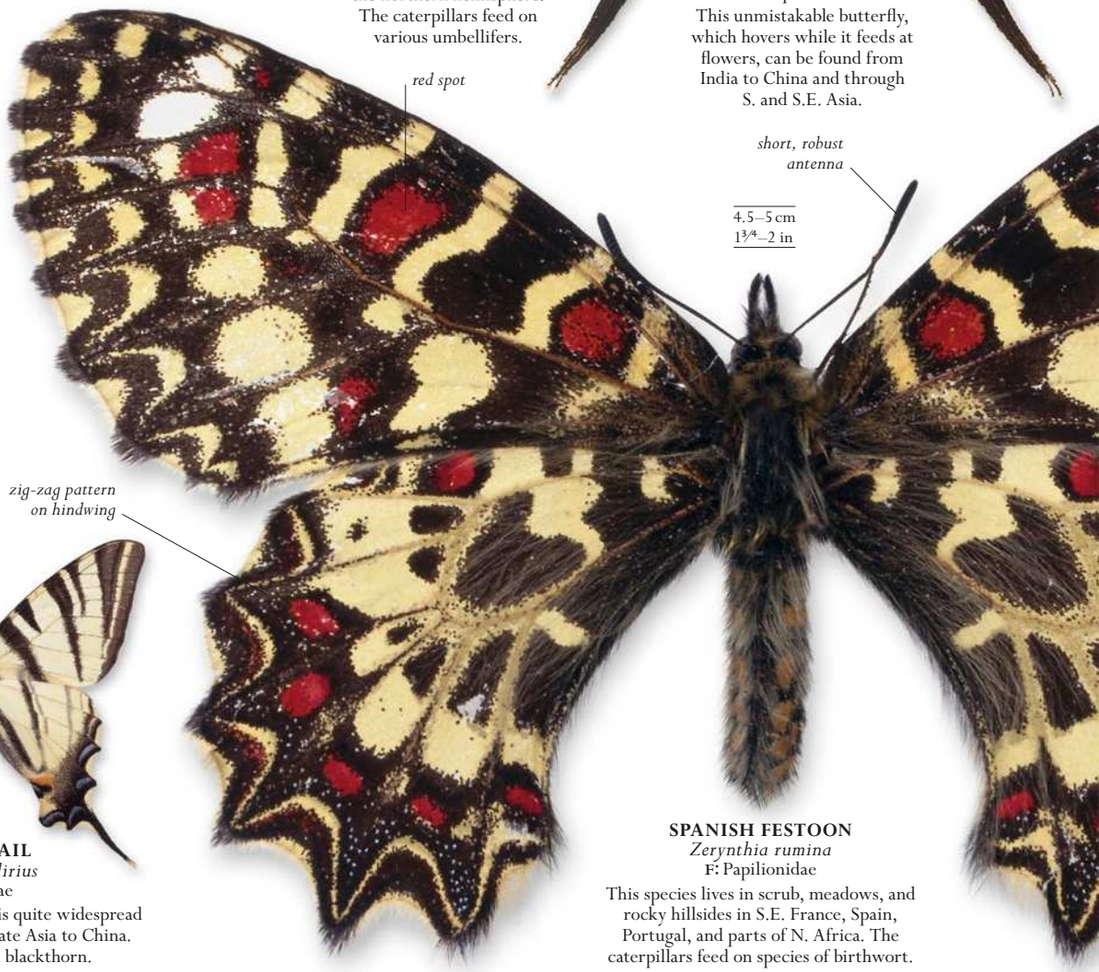
GREEN DRAGONTAIL
Lamproptera meges
F: Papilionidae

This unmistakable butterfly, which hovers while it feeds at flowers, can be found from India to China and through S. and S.E. Asia.

6–9 cm
2¼–3½ in

APOLLO
Parnassius apollo
F: Papilionidae

This butterfly can be found in flower-rich meadows in mountainous regions of Europe and Asia. The caterpillars feed on stonecrop.



SPANISH FESTOON
Zerynthia rumina
F: Papilionidae

This species lives in scrub, meadows, and rocky hillsides in S.E. France, Spain, Portugal, and parts of N. Africa. The caterpillars feed on species of birthwort.

8–9 cm
3¼–3½ in

BLUE TRIANGLE
Graphium sarpedon
F: Papilionidae

Common and widespread from India to China, Papua New Guinea, and Australia, this butterfly feeds on nectar and drinks from puddles.

7–8 cm
2¾–3¼ in

SCARCE SWALLOWTAIL
Iphiclides podalirius
F: Papilionidae

Despite its name, this species is quite widespread in Europe and across temperate Asia to China. The caterpillars feed on blackthorn.

8–14 cm
3¼–5½ in

TIGER SWALLOWTAIL
Papilio glaucus
F: Papilionidae

This species is widespread in N. America. The young caterpillars, which resemble bird droppings, feed on a variety of trees and shrubs.

SMALL COPPER
Lycaena phlaeas
F: Lycaenidae

Common in Europe, N. Africa, and Asia as far as Japan, this species can also be found in N. America. The caterpillars feed on sorrels and docks.

2.5–3 cm
1–1¼ in

3–4 cm
1¼–1½ in

3.5–4.5 cm
1½–1¾ in

BROWN HAIRSTREAK
Thecla betulae
F: Lycaenidae

This species can be found in hedgerows, scrubland, and woodland across Europe and temperate Asia. The caterpillars feed at night on blackthorn.

BLUE THAROPS
Menander menander
F: Lycaenidae

This fast-flying butterfly occurs in tropical forests from Panama to northern S. America. Little is known about its life cycle or caterpillars.

2.5–3.5 cm
1–1½ in

ADONIS BLUE
Lysandra bellargus
F: Lycaenidae

This European species can be found in chalky grassland, where the caterpillars feed on horseshoe vetch. The male is sky blue while the female is brown.

2–2.5 cm
¾–1 in

SONORAN BLUE
Philotes sonorensis
F: Lycaenidae

This rare butterfly is restricted to rocky washes and desert cliffs in California. The caterpillars feed on succulents known as stonecrop or "live-forever" plants.

3–4 cm
1¼–1½ in

DUKE OF BURGUNDY FRITILLARY
Hamearis lucina
F: Lycaenidae

This species ranges across C. Europe as far as the Urals and favours flower meadows, where its food plants, cowslip and primrose, grow.

SAWFLIES, WASPS, BEES, AND ANTS

Hymenoptera typically have two pairs of wings, joined in flight by tiny hooks. Apart from sawflies, they have a "wasp-waist" and females have an ovipositor that may be modified to sting. Many wasps are predatory or parasitic. Bees are vital pollinators and ants play a role in many ecosystems.

STEM SAWFLY
Cephus nigrinus
F: Cephidae

This slender, all-black sawfly is widespread in W. Europe. The larvae bore downwards inside the stems of wild and some cultivated grasses.

7–9 mm
7/32–11/32 in

1.8–2.2 cm
¾–9/10 in

CIMBICID SAWFLY
Trichiosoma lucorum
F: Cimbicidae

This stout-bodied European sawfly is found in woodland, hedgerows, and scrubby areas. The larvae feed on birch and willow.

7–9 mm
7/32–11/32 in

fine tufts on wing margin

TENTHREDO ARCUATA
F: Tenthredinidae

Widespread in meadows, this distinctive black- and yellow-marked European sawfly lays its eggs on clovers.

2–4 cm
¾–1½ in

slender antennae

large head

PERGID SAWFLY
Unknown sp.
F: Pergidae

These herbivorous insects are found in Australia and S. America. Many species attack eucalyptus trees, and young larvae feed gregariously.

2 cm
¾ in

7–9 mm
7/32–11/32 in

7–10 mm
7/32–3/8 in

ROSE SAWFLY
Arge ochropus
F: Argidae

Recognizable by the black along the wing edge, this European sawfly visits flat-topped flowers to feed. The larvae feed on wild roses.

RED-HEADED SAWFLY
Acantholyda erythrocephala
F: Pamphiliidae

Originally found in Europe and Asia, this sawfly has spread to North America. The larvae feed communally under silken webs among pine needles.

HORNTAIL
Urocerus gigas
F: Siricidae

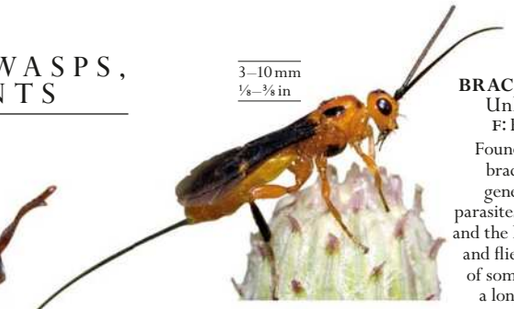
This impressive species can be found across the northern hemisphere. The female drills deep into softwood trees to lay her eggs.

ovipositor

» SAWFLIES, WASPS, BEES, AND ANTS

1–3 mm
1/32–1/8 in

FIG WASP
Unknown sp.
F: Agaonidae
Fig wasps are found in tropical and subtropical regions. Many are essential pollinators, breeding inside specific species of fig.

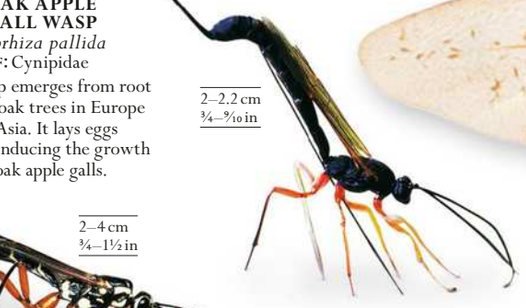


3–10 mm
1/8–3/8 in

BRACONID WASP
Unknown sp.
F: Braconidae
Found worldwide, braconid wasps generally live as parasites on caterpillars and the larvae of beetles and flies. The females of some species have a long ovipositor.

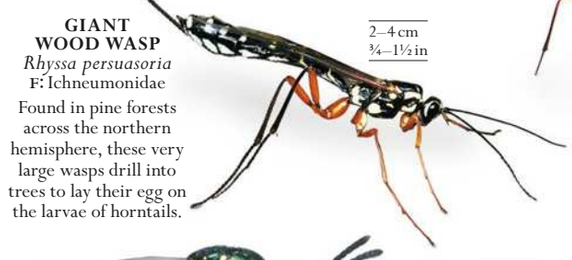
5–6.5 mm
3/16–3/10 in

OAK APPLE GALL WASP
Biorhiza pallida
F: Cynipidae
This wasp emerges from root galls on oak trees in Europe and Asia. It lays eggs in buds, inducing the growth of oak apple galls.



2–2.2 cm
3/4–9/10 in

***LISSONOTA* SP.**
F: Ichneumonidae
The genus *Lissonota* contains many very similar wasps. This species drills into a trunk to lay its eggs in a wood-boring moth larva.



2–4 cm
3/4–1 1/2 in

GIANT WOOD WASP
Rhyssa persuasoria
F: Ichneumonidae
Found in pine forests across the northern hemisphere, these very large wasps drill into trees to lay their egg on the larvae of horntails.

1–3 mm
1/32–1/8 in

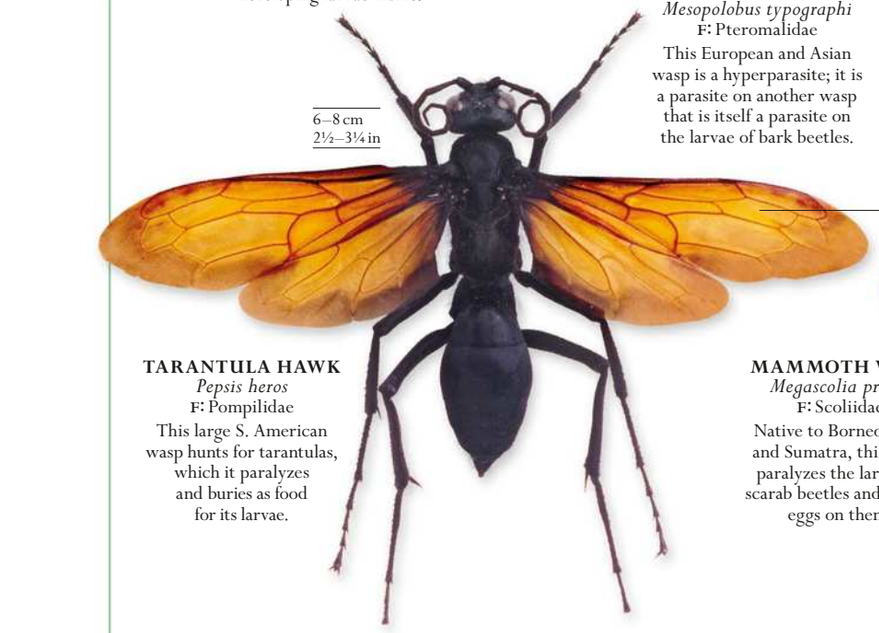
***TORYMUS* SP.**
F: Torymidae
This wasp uses her long ovipositor to drill through gall tissue and lay eggs on the developing larvae inside.

3–4 mm
1/8–5/32 in

PTEROMALID WASP
Mesopolobus typographi
F: Pteromalidae
This European and Asian wasp is a hyperparasite; it is a parasite on another wasp that is itself a parasite on the larvae of bark beetles.

1–1.6 cm
3/8–1/2 in

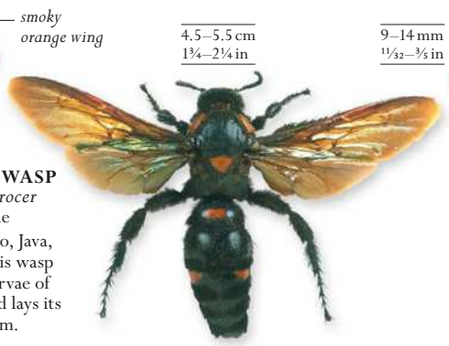
CHALCID WASP
Chalcis sispes
F: Chalcididae
This wasp is found in Europe and parts of Asia, where it lives as a parasite on the aquatic larvae of large soldier flies.



6–8 cm
2 1/2–3 1/4 in

smoky orange wing

TARANTULA HAWK
Pepsis heros
F: Pompilidae
This large S. American wasp hunts for tarantulas, which it paralyzes and buries as food for its larvae.



4.5–5.5 cm
1 3/4–2 1/4 in

9–14 mm
11/32–3/5 in

MAMMOTH WASP
Megascolia procer
F: Scoliidae
Native to Borneo, Java, and Sumatra, this wasp paralyzes the larvae of scarab beetles and lays its eggs on them.

large compound eye

bright metallic coloration

1.8–2 cm
7/10–3/4 in

SPLENDID EMERALD WASP
Stilbum splendidum
F: Chrysididae
This large wasp from N. Australia lives as a parasite on the larvae of solitary mud-nesting wasps. They are known to visit flowers to feed.

hard, dimpled body surface gives protection from stings

1.3–1.5 cm
1/2–3/5 in

EUROPEAN BEEWOLF
Philanthus triangulum
F: Crabronidae
Found in S. and C. Europe and N. Africa, this wasp makes a nest in sandy areas stocked with honey bees as food for its larvae.

VELVET ANT
Mutilla europaea
F: Mutillidae
This European species lives in sandy areas and rough grassland. The female is wingless, and the larvae eat the larvae of bumble bees.

7.5–12 mm
5/16–1/2 in

TIPHIID WASP
Methocha articulata
F: Tiphiidae

The wingless females of this European species live in sandy areas, where they are a parasite on the larvae of tiger beetles inside their burrows.

HORNET
Vespa crabro
F: Vespidae

This large social wasp lives in Europe and Asia and has been introduced elsewhere. It favours woodland, where it makes its nest in hollow trees.

1.5–3 cm
1/2–1 1/4 in

1.4–2.2 cm
1/2–3/4 in

BUFF-TAILED BUMBLE BEE
Bombus terrestris
F: Apidae

This social bee, which is native to C. and S. Europe and N. Africa, has been introduced elsewhere. It is an important crop pollinator.

very hairy body

wasp-waist

1.2–1.9 cm
1/2–3/4 in

COMMON WASP
Vespula vulgaris
F: Vespidae

Native to the northern hemisphere, this wasp feeds its young on insects and makes a paper nest from chewed wood fibres.

TAWNY MINING BEE
Andrena fulva
F: Andrenidae

Found in C. Europe, this early spring bee makes a nest underground in grassy areas, raising a little mound of soil at the entrance.

9–15 mm
11/32–3/5 in

1.2–1.6 cm
1/2 in

HONEY BEE
Apis mellifera
F: Apidae

The western honey bee, an important crop pollinator, is now found worldwide. In the wild it nests in hollow trees, but is widely kept in domestic hives.

1.2–1.4 cm
1/2 in

ORCHID BEE
Euglossa asarophora
F: Apidae

Like all orchid bees, this species lives in colonies in the rainforests of S. America. Males collect oils and resins from orchids to attract a mate.

1.1–1.3 cm
2/5–1/2 in

PLASTERER BEE
Colletes sp.
F: Colletidae

These solitary, ground-nesting bees are common across the northern hemisphere. They line their nests with a waterproof abdominal secretion.

3.3–3.6 cm
1 1/4–1 1/2 in

GREAT CARPENTER BEE
Xylocopa latipes
F: Anthophoridae

Found all over S.E. Asia, this large bee excavates nest cavities in tree branches or wooden timbers and posts.

5–9 mm
3/16–11/32 in

WOOD ANT
Formica rufa
F: Formicidae

Common throughout Europe, this ant is an important predator of insects in forests. It squirts formic acid from the rear of its abdomen as a defence.

1.6 cm
3/5 in

LEAF-CUTTER ANT
Atta sp.
F: Formicidae

Leaf-cutter ants live in C. and S. America. They can make vast underground nests, where they cultivate a special fungus on chewed leaf fragments as food.

compound eye

band of pale hair

1.1–1.7 cm
3/8–1/2 in

WOOL CARDER BEE
Anthidium manicatum
F: Megachilidae

This European bee makes nests in existing holes in wood or masonry, which it lines with hairs that it collects from certain plants.

1.3–2 cm
1/2–3/4 in

SWEAT BEE
Halictus quadricinctus
F: Halictidae

This solitary bee is found across S. Europe and the Mediterranean. It makes large clusters of cells underground in which to rear its young.

SOLDIER

3–12 mm
1/8–1/2 in

ARMY ANT
Eciton burchellii
F: Formicidae

This S. American ant forms large colonies of up to 2 million individuals and attacks large prey.

RIBBON WORMS

Marine worms of the phylum Nemertea are voracious predators, seizing their prey with a proboscis and swallowing it whole or sucking its fluids.

PHYLUM	NEMERTEA
CLASSES	4
ORDERS	4
FAMILIES	48
SPECIES	1,350

Ribbon worms are soft slimy animals, cylindrical in shape or somewhat flattened. Many simply wriggle across the seabed, but some can also swim. One species, *Lineus longissimus*, the bootlace worm, has been recorded growing to 30 m (100 ft) in length. Like others, it has a fragile body that is easily broken.

The proboscis of a ribbon worm is not part of its gut, but emerges from a sac on its head just above the mouth. In some species the proboscis has sharp spikes for gripping or piercing prey, and even venom for immobilizing it. These well-armed species prey on other invertebrates, such as crustaceans, polychaete worms, and molluscs. Other ribbon worms feed on dead material.

25–30 cm
10–12 in

PACIFIC STRIPED RIBBON WORM
Baseodiscus hemprichii
F: Valenciniidae

This colourful ribbon worm lives on reefs of the Indo-Pacific. It hunts for invertebrate prey on the bottom of the sea.

8–10 cm
3–4 in

RED RIBBON WORM
Nipponnemertes pulchra
F: Cratenemertidae

Found in cold, ocean waters around the world, this ribbon worm varies in colour from orange to pink or red.

COMMON ATLANTIC RIBBON WORM
Tubulanus annulatus
F: Tubulanidae

A large ribbon worm, this species lives in muddy sediment in intertidal or offshore waters of the N.E. Atlantic and Mediterranean.

12–75 cm
4¾–30 in

BRYOZOANS

These minute animals form coral-like colonies, filter-feeding with microscopic tentacles and, in turn, providing food for grazing invertebrates.

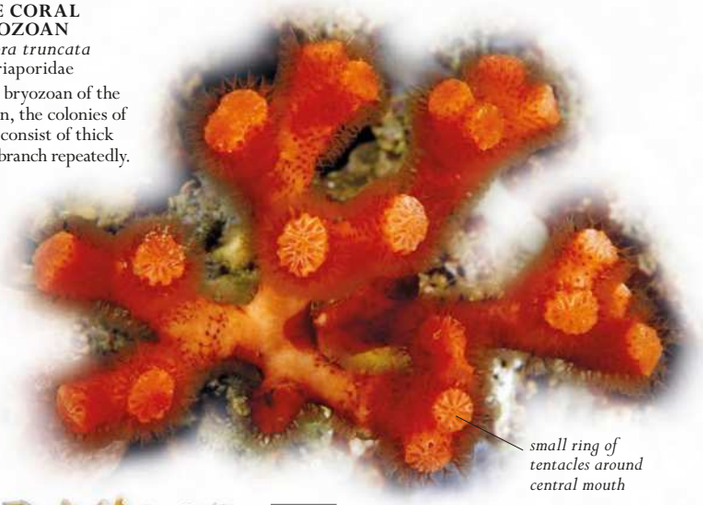
PHYLUM	BRYOZOA
CLASSES	3
ORDERS	7
FAMILIES	About 160
SPECIES	6,409

Many bryozoans resemble coral, but they are more advanced animals than cnidarians. A colony – genetically a single individual – is made up of thousands of tiny bodies called zooids, each consisting of a retractable fan of tentacles surrounding the mouth. Microscopic, beating hairs on the tentacles waft particles of food down to the mouth, which leads into a U-shaped gut. Waste exits by the anus in the body wall. Although a hand lens is needed to see individual zooids, colonies assume a variety of forms, depending upon species. Some are encrustations on rock or seaweed, others grow into bristly thickets or fleshy lobes. Many are heavily calcified like stony corals; others are soft.

FALSE CORAL BRYOZOAN
Myriapora truncata
F: Myriaporidae

A distinctive bryozoan of the Mediterranean, the colonies of this species consist of thick cylinders that branch repeatedly.

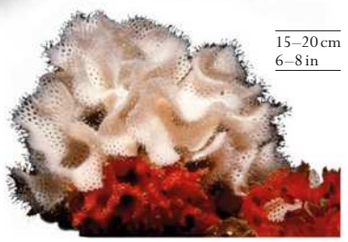
3–4 cm
1⅛–1¼ in



10–20 cm
4–8 in

HORNWRACK
Flustra foliacea
F: Flustridae

Typical of its family, this bryozoan forms erect leafy colonies. This stiff bushy offshore species is common on rocky N. European coasts.



15–20 cm
6–8 in

PINK LACE BRYOZOAN
Iodictyum phoeniceum
F: Phidoloporidae

Lace bryozoans – sometimes inaccurately called "lace corals" – form tall, rigid colonies. This colourful species lives on coastlines around S. and E. Australia.

5–20 cm
2–8 in

LACY CRUST BRYOZOAN
Membranipora membranacea
F: Membraniporidae

The bryozoans known as sea mats grow in encrusting lacy sheets. This species forms fast-growing colonies on kelp fronds of the N.E. Atlantic.

LAMPSHELLS

Lampshells look very like bivalve molluscs, but feed instead with tentacles. They belong to a different, very ancient phylum.

PHYLUM	BRACHIOPODA
CLASSES	3
ORDERS	5
FAMILIES	About 30
SPECIES	414

The soft body of a lampshell is enclosed within a two-valved shell that has one valve larger than the other. The shell is either attached to the seabed with a rubbery stalk or is directly cemented to rock. The shell valves are positioned top-and-bottom around the animal – not around the sides, as in bivalve molluscs. Like molluscs, lampshells have a fleshy mantle attached to the inner surface of the shell, which encloses a mantle cavity. In the mantle cavity there is a ring of tentacles with microscopic beating hairs that drive particles to a central mouth – just like the feeding structure in bryozoans.

The fossil record shows that lampshells were much more common and demonstrated much greater diversity in the warm, shallow seas of the Paleozoic Era. They began to decline dramatically during the time of the dinosaurs – perhaps because bivalve molluscs were more successful.

2–3 cm
¾–1¼ in

EUROPEAN LAMPSHELL
Terebratulina retusa
F: Cancellothyrididae

Found from the N.E. Atlantic to the Mediterranean, this lampshell has pear-shaped valves and attaches to vertical rocks using a short stalk.

3–5.5 cm
1¼–2¼ in

hinged, two-valved shell

PACIFIC LAMPSHELL
Terebratalia transversa
F: Terebrataliidae

An abundant lampshell of the northern Pacific, this short-stalked species has a variable smooth or ribbed shell.

1–1.5 cm
⅜–½ in

INARTICULATED LAMP SHELL
Novocrania anomala
F: Craniidae

A brachiopod of North Atlantic waters, this species cements its shell to rock, and superficially resembles a limpet.

MOLLUSCS »

Molluscs are a large, highly diverse group, ranging from blind filter-feeding bivalves cemented to rock, through voraciously grazing snails and slugs, to lively, intelligent octopus and squid.

PHYLUM	MOLLUSCA
CLASSES	9
ORDERS	53
FAMILIES	609
SPECIES	71,719

A typical mollusc has a soft body carried on a large muscular foot, and a head that senses the world using eyes and tentacles. The viscera (internal organs) are contained in a visceral hump, which is covered by a fleshy mantle. This mantle overhangs the edge of the hump, creating a groove called the mantle cavity, which is used for breathing. In most species, this mantle also secretes substances used to make the shell. Most molluscs feed with a tongue called a radula. Coated in teeth made of chitin, the radula moves forwards and backwards through the mouth to rasp at food. Bivalves lack a radula. They feed instead by siphoning water through their shell. Most species trap particles of food in the mucus on their gills.

These limpets have grazed the rock around them bare, but they cannot reach the green algae growing on top of their own shell.

WITH AND WITHOUT SHELLS

A shell is not only a refuge from predators: it is also protection from drying out. Some snails even have a trapdoor called an operculum to seal the opening of the shell. The shell is hardened with minerals obtained from the diet and surrounding water. It is coated in tough protein; and smooth on the inside, to allow the body to slide in and out – some groups have a lining of mother-of-pearl. Many shell-less molluscs defend themselves with chemicals that make them distasteful, or even poisonous, and advertise this with striking colours.

Most cephalopods – tentacled molluscs, such as octopus and squid – lack an obvious shell. Members of this group are entirely predatory and have a horny beak for chewing on flesh. Their muscular foot is modified into their characteristic tentacles, which are used for grasping and swimming.

GETTING OXYGEN

Most molluscs are aquatic and so they have gills for breathing, usually projecting into the mantle cavity and irrigated by a current of water. In most land snails and slugs the mantle cavity is filled with air and functions as a lung. Because many freshwater snails probably evolved from this group, they have a lung too, and must frequently surface to breathe.

APLACOPHORANS

More worm-like than mollusc-like, the Aplacophora are small cylindrical burrowers that feed on detritus or other invertebrates in the sediment of deep oceans. They lack a shell, but their clearly molluscan features include a rasping, tongue-like radula. The mantle cavity is reduced to an opening at the rear of the body, into which the animal discharges waste from the gut.

3 mm–8 cm
⅛–3¼ in

COMMON GLISTENWORM
Chaetoderma sp.
F: Chaetodermatidae

This worm-like mollusc is covered by a tough cuticle. It burrows through muddy sediment in the depths of the North Atlantic.

BIVALVES

Highly specialized aquatic molluscs, bivalves are instantly recognizable, with a hinged shell that opens up to access food and oxygen-rich water.

Bivalves are identifed from their shell, which consist of two plates, called valves, joined together by a hinge. To protect against predators and the dangers of drying out, the shell clamps tightly shut by contracting powerful muscles, sealing most or all of the body inside. Seashore species are regularly exposed by receding tides.

Within the class there is a huge variation in size, ranging from the tiny fingernail clam at about 6 mm (¼ in) to the giant clam, which can grow to 1.4 m (4½ ft) across. Some bivalves attach to rocks and hard surfaces by a bundle of tough threads, called a byssus. Others use a well-developed muscular foot for burrowing into muddy sediment. A few bivalves, such as scallops, swim freely, using a method of jet propulsion.

Water is pumped in and out of the shell through tubes, called siphons. The water supplies oxygen and food, which are collected as the water passes over modified gills. Food particles caught in the sticky mucus around the gills are wafted towards the mouth by microscopic hairs.

BIVALVES AND PEOPLE

Mussels, clams, and oysters are important sources of food, and some oysters create fine quality pearls by coating a foreign object with layers of nacre. Bivalves are also useful indicators of water quality as many cannot survive high levels of pollution.

PHYLUM	MOLLUSCA
CLASS	BIVALVIA
ORDERS	19
FAMILIES	105
SPECIES	9,733

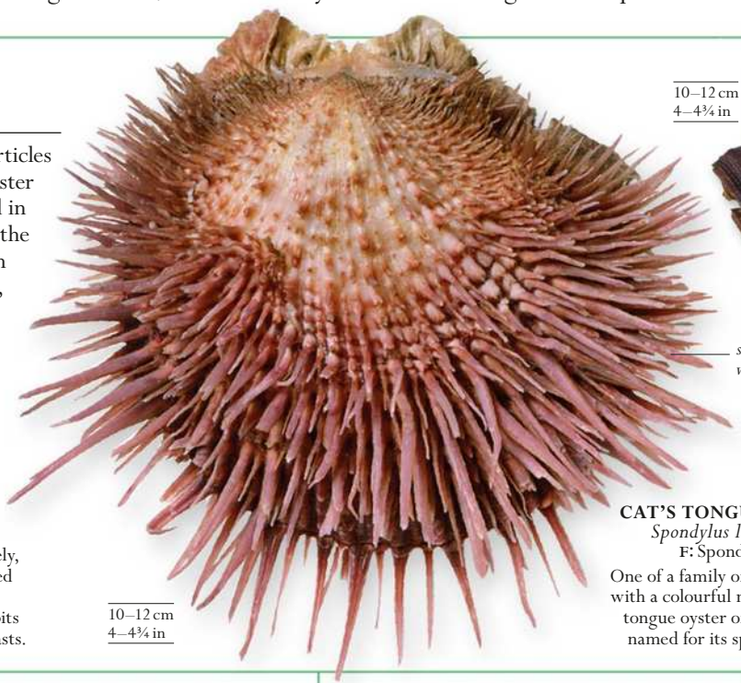
A queen scallop claps the two valves of its shell together to accelerate away from the unwelcome attention of a predatory starfish.

OYSTERS AND SCALLOPS

The Ostreoida feed on tiny food particles filtered from the seawater. Many oyster species live permanently submerged in coastal waters, fixed to the rock by the gland that produces byssus thread in other bivalves. Scallops, by contrast, can swim freely by clapping their valves open and shut.

12–15 cm
4¾–6 in

GREAT SCALLOP
Pecten maximus
F: Pectinidae
As well as swimming freely, scallops have jet-propelled escape responses. This commercial species inhabits fine sands of European coasts.



spiny left valve

10–12 cm
4–4¾ in

10–12 cm
4–4¾ in

COCK'S COMB OYSTER
Lopha cristagalli
F: Ostreidae
Close relatives of scallops, many species of oyster are prized as food and for their pearls. This is an Indo-Pacific species.

8–10 cm
3¼–4 in

EDIBLE OYSTER
Ostrea edulis
F: Ostreidae
Formerly abundant in Europe, this commercially important species is now over-fished in some areas. The species is inedible during summer months when breeding.

CAT'S TONGUE OYSTER
Spondylus linguafelis
F: Spondylidae
One of a family of thorny oysters with a colourful mantle, the cat's tongue oyster of the Pacific is named for its spiny exterior.

ARC CLAMS AND RELATIVES

The shell of these bivalves is closed by two strong muscles, and hinge along a straight line bearing a continuous series of teeth. Like their relatives, the Arcoida have a reduced foot and large gills that help trap food particles.

5–7 cm
2–2¾ in

NOAH'S ARK
Arca noae
F: Arcidae
Arc shells are square-edged, thick-shelled bivalves. Noah's Ark is a byssus-attached intertidal species on rocky coasts of the E. Atlantic.

5–6 cm
2–2¼ in

EUROPEAN BITTERSWEET
Glycymeris glycymeris
F: Glycymerididae
Dog shells are rounded relatives of arc shells. This N.E. Atlantic species, fished in Europe, has a sweet flavour but is tough when overcooked.

MARINE MUSSELS

The Mytiloida have a distinctively shaped elongate, asymmetrical shell that attaches to rocks by byssus threads. Only one of their two shell-closing muscles is well developed.

8–10 cm
3¼–4 in

COMMON MUSSEL
Mytilus edulis
F: Mytilidae
The most commercially important mussel in Europe, this long-lived species occurs in dense beds. It can tolerate the low salinity of estuarine waters.

FAN MUSSELS AND RELATIVES

Members of the Pterioida include long-hinged, winged oysters and T-shaped hammer-oysters as well as fan mussels. The group also contains commercially important marine pearl oysters.

25–40 cm
10–16 in

FLAG FAN MUSSEL
Atrina vexillum
F: Pinnidae
Fan mussels, such as this species from western European coastlines, have a triangular shell attached by a byssus in soft sediment.

FRESHWATER MUSSELS

The Unionoida are the only exclusively freshwater order of bivalves. The tiny larvae use their valves to clamp onto fish, forming cysts on the gill fins and feeding on blood or mucus before dropping off as juvenile mussels.

9–10 cm
3½–4 in

SWAN MUSSEL
Anodonta sp.
F: Unionidae
Bitterling fish lay eggs in living freshwater mussels, such as this Eurasian species. The mollusc becomes a nursery for fish fry.

10–15 cm
4–6 in

FRESHWATER PEARL MUSSEL
Pinctada margaritifera
F: Margaritiferidae
Well known for its good-quality pearls, this mussel lives buried in sand or gravel beneath fast-flowing rivers in Eurasia and N. America.

TRUE CLAMS AND BORING BIVALVES

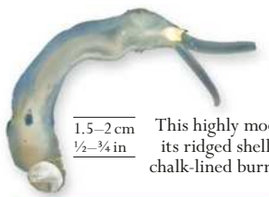
Long-siphoned bivalves in the order Myoida typically burrow in mud or bore through wood or rock. In piddocks the front of the shell acts like a file to bore burrows in soft rock. Shipworms use their shell valves to drill through timber.

12–15 cm
4¾–6 in

COMMON PIDDOCK
Pholas dactylus
F: Pholadidae
This common piddock of the N.E. Atlantic is phosphorescent and, like other species, lives in burrows bored in wood or clay.

12–15 cm
4¾–6 in

SOFT SHELL CLAM
Mya arenaria
F: Myidae
An edible clam with a thin shell, this N. Atlantic species is especially abundant in muddy estuaries, where it burrows in soft sediment.


1.5–2 cm
½–¾ in

SHIPWORM
Teredo navalis
F: Teredinidae
This highly modified, widespread bivalve uses its ridged shell valves as a drill to bore deep, chalk-lined burrows in timber, damaging ships.

WATERING POTS AND RELATIVES

The order Pholadomyoida includes clams and tropical watering pots. Scarcely recognizable as bivalves, watering pots live encased in chalky tubes, and draw detritus and water into the tube through a perforated plate at the anterior end.

15–17 cm
6–6½ in

PHILIPPINE WATERING POT
Verpa philippinensis
F: Penicillidae
This bizarre Indo-Pacific watering pot belongs to a family named for their wide, perforated ends, fringed with tubules. It lives partially buried in sediment.

COCKLES AND RELATIVES

The largest order of bivalves, the Veneroida include a large range of marine animals. Most have short siphons that are often fused together. Some, notably the cockles, are agile, capable of burrowing or even leaping with their foot. Others are attached to rocks by a byssus.

3–4 cm
1¼–1½ in

ZEBRA MUSSEL
Dreissena polymorpha
F: Dreissenidae
This freshwater mussel is anchored by byssus threads, but can detach and crawl on a slender foot. Native to E. European waters, it has spread elsewhere.

15–20 cm
6–8 in

SWORD RAZOR CLAM
Ensis siliqua
F: Pharidae
Razor shells, such as this N.E. Atlantic species, live in burrows, feeding and respiring through their emergent siphon, but drop quickly using their muscular foot when disturbed.

2–4 cm
¾–1½ in

CRADLE DONAX
Donax cuneatus
F: Donacidae
One of a family of triangular wedge shells that are fast burrowers in surf, this is a tropical Indo-Pacific species.

5–6 cm
2–2¼ in

OBLONG TRAPEZIUM
Trapezium oblongum
F: Trapezidae
An Indo-Pacific bivalve, this animal lives attached to rocks by byssus threads, usually in crevices or beneath coral rubble.

4–5 cm
1½–2 in

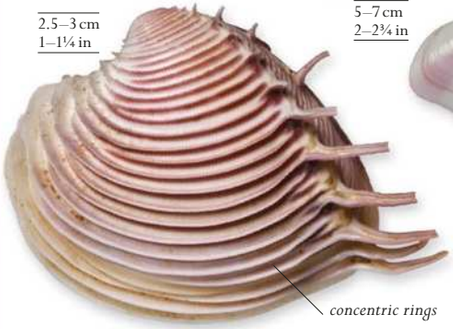
COMMON EDIBLE COCKLE
Cerastoderma edule
F: Cardiidae
Sand-burrowing cockles have a shell with radiating ribs. This N.E. Atlantic species, often found in vast numbers, is fished in N. Europe.

5–7 cm
2–2¾ in

SUNRISE TELLIN
Tellina radiata
F: Tellinidae
The shell of this tellin from the Caribbean has a variable banding pattern and is often found on beaches.

8–9 cm
3¼–3½ in

WEST AFRICAN TELLIN
Peronaea madagascariensis
F: Tellinidae
Tellins, such as this rose-coloured tropical species, feed on particles in sediment, drawn in through their long, extendable siphon.



2.5–3 cm
1–1¼ in

ROYAL COMB VENUS
Hysteroconcha dione
F: Veneridae
Named after the comb-like spines on its shell, this Venus clam occurs on tropical American coastlines.

3–4 cm
1¼–1½ in

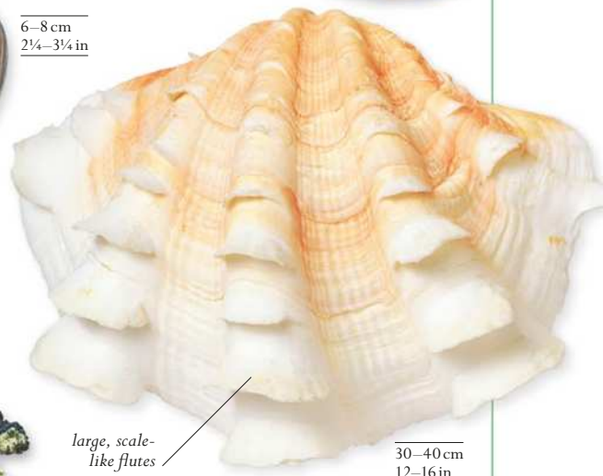
STRIPED TELLIN
Tellinella virgata
F: Tellinidae
This Indo-Pacific species has a decoratively patterned shell, as do many tellins.

5–8 cm
2–3¼ in

RED CALLISTA
Callista erycina
F: Veneridae
Many Venus clams are prized by collectors, including this Indo-Pacific species, also known as the sunset clam.

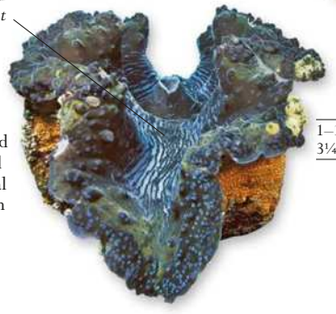
6–8 cm
2¼–3¼ in

RINGED DOSINIA
Dosinia anus
F: Veneridae
This Venus clam is found on the coastlines of New Zealand, and is one of many species harvested for human consumption.



30–40 cm
12–16 in

FLUTED GIANT CLAM
Tridacna squamosa
F: Cardiidae
Like other Indo-Pacific giant clams, this species opens its shell during the day so that algae in its coloured mantle can photosynthesize to make food.



1–1.4 m
3¼–4½ ft

GIANT CLAM
Tridacna gigas
F: Cardiidae
The world's largest bivalve, this long-lived and now endangered coral-dwelling animal lives on sandy beds in the Indo-Pacific.

GASTROPODS

Gastropods are by far the largest class of molluscs. The word gastropod means "stomach-foot", because the animal appears to crawl on its belly.

Most snails and slugs glide along a stream of slime on a single muscular foot, rasping at their food with a radula, a tongue-like emery-paper. Most gastropods use their radula to rasp at vegetation, algae, or the fine film of microbes that coat underwater rocks, but some are predatory. They usually have a distinct head with well-developed sensory tentacles. Snails have a coiled or helical shell into which they can withdraw; slugs lost their shell during the course of evolution. The class also includes a number of animals that deviate from this basic plan, such as swimming sea slugs. Gastropods originated in the oceans and they still have their greatest diversity there; other species live in fresh water or on land.

TORSION

The juvenile gastropod undergoes a process called torsion: the whole of the body within the shell twists round 180 degrees, so that the respiratory mantle cavity comes to lie above the animal's head. This allows the vulnerable head to withdraw into the safety of the shell. In marine snails, such as periwinkles and limpets, this body form persists into adulthood. Because of this, marine snails are described as prosobranchs, meaning "forward gills". In sea slugs, however, the body twists back again, and they are called opisthobranchs, or "hind gills".

PHYLUM	MOLLUSCA
CLASS	GASTROPODA
ORDERS	21
FAMILIES	409
SPECIES	About 67,000

DEBATE

A COMMON TWIST

Sea snails were originally grouped together because their body twists during development so that their gills face forwards. But the ancestor of all snails probably had this feature, and now marine snails are split into groups based on other characteristics. Their exact relationships remain debatable.

TRUE LIMPETS

Primitive algae-grazing limpets, the Patellogastropoda have a slightly coiled, conical shell. Their powerful muscles clamp down firmly on intertidal rocks, protecting them from predators, desiccation, and waves.

3–5 cm
1¼–2 in

COMMON LIMPET
Patella vulgata
F: Patellidae

This species grazes algae from rocks on shores of the N.E. Atlantic at high tide, then returns to a depression in the rock that matches the shape of its shell.

NERITES AND RELATIVES

A small but diverse group, Cycloneritimorpha are well known in the fossil record. They include marine, freshwater, and land-living forms, some with a coiled shell, and a few like limpets. There are also species with a trapdoor to their shell.

2–5 cm
¾–2 in

1.2–2 cm
½–¾ in

ZIG-ZAG NERITE
Neritina communis
F: Neritidae

An inhabitant of Indo-Pacific mangroves, this is a highly variable species, with white, black, red, or yellow shells even in the same population.

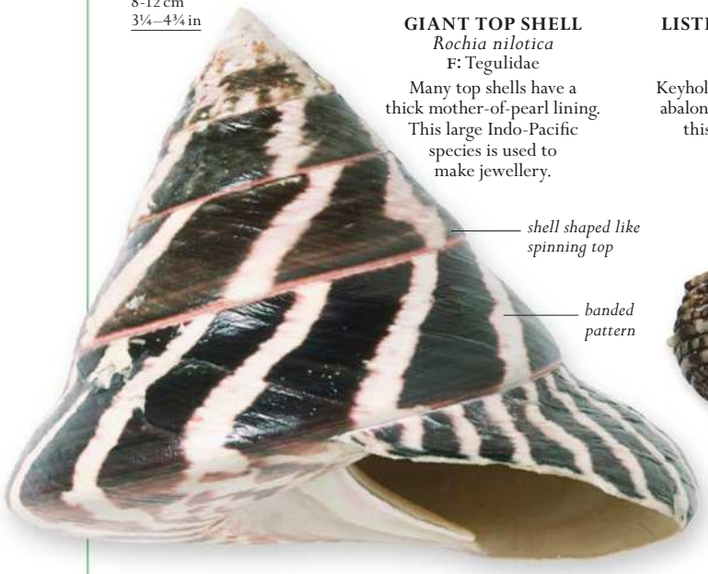
BLEEDING TOOTH NERITE
Nerita peloronta
F: Neritidae

Named for the blood-red mark on its shell opening, this Caribbean intertidal mollusc can survive out of water for prolonged periods.

TOP SHELLS AND RELATIVES

The Vetigastropoda are marine gastropods that graze algae and microbes with a brush-like radula. The shells range from those of keyhole limpets, with the barest suggestion of a spire, to the coiled globes and pyramids of top shells, which can seal themselves inside using an operculum, or trapdoor.

8–12 cm
3¼–4¾ in



GIANT TOP SHELL
Rochia nilotica
F: Tegulidae

Many top shells have a thick mother-of-pearl lining. This large Indo-Pacific species is used to make jewellery.

LISTER'S KEYHOLE LIMPET
Diodora listeri
F: Fissurellidae

Keyhole limpets are close relatives of abalones and top shells. Like others, this W. Atlantic species ejects oxygen-depleted water through its "keyhole".

5–7 cm
2–2¾ in

SILVER MOUTH TURBAN SHELL
Turbo argyrostomus
F: Turbinidae

Turban shells are close relatives of top shells, but have a calcified operculum. This is an Indo-Pacific species.

1.5–4.5 cm
½–1¾ in

2–2.5 cm
¾–1 in

CHECKERED TOP SHELL
Phorcus turbinatus
F: Trochidae

Top shells have a "spinning-top" shell that is closed with a circular operculum. This is a Mediterranean species.

20–30 cm
8–12 in

RED ABALONE
Haliotis rufescens
F: Haliotidae

Abalones have an ear-shaped shell lined with thick mother-of-pearl and punctuated with holes for exhaling water. This N.E. Pacific kelp-grazing species is the largest.

TOWER SHELLS AND RELATIVES

These tall-spired snails typically live in muddy or sandy sediment. They feed on particles in the water that they circulate through their mantle cavity. The Cerithioidea are found in marine, freshwater, and estuarine habitats. They are slow moving and often group together in very large numbers.

2.5–5.5 cm
1–2¼ in

GREAT SCREW SHELL
Turritella terebra
F: Turritellidae

A filter feeder of muddy sediments, this Indo-Pacific snail belongs to a group variously known as tower shells or auger shells.

6–17 cm
2⅜–6½ in

ROUGH CERITH
Rhinoclavis aspera
F: Cerithiidae

Ceriths are snails often abundant in shallow-water tropical marine sediments. Like others, this Indo-Pacific species lays strings of eggs attached to solid material.

WEST INDIAN WORM SHELL
Vermicularia spirata
F: Turritellidae

Free-floating males of this Caribbean unwound screw shell attach to solid material, often embedding themselves in sponges. They then develop into larger sedentary females.

2.5–16 cm
1–6½ in

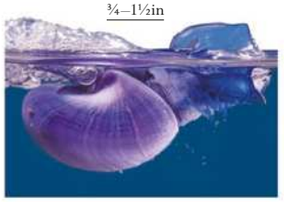
PERIWINKLES, WHELKS, AND RELATIVES

The largest and most diverse order of marine snails, the Caenogastropoda are divided into several groups. Epitoniids, including wentletraps (bottom-living) and violet snails (floating), are specialist predators of cnidarians. Littorinids graze on algae, and include periwinkles, cowries, and conches. Whelks and their relatives are predators that project a long siphon out through a groove in the shell.

2.5–7 cm
1–2¾ in

PRECIOUS WENTLETRAP
Epitonium scalare
F: Epitoniidae

Wentletraps (from the German for spiral staircase) prey on anemones and corals and have cutting jaws. This is an Indo-Pacific species.



2–4 cm
¾–1½ in

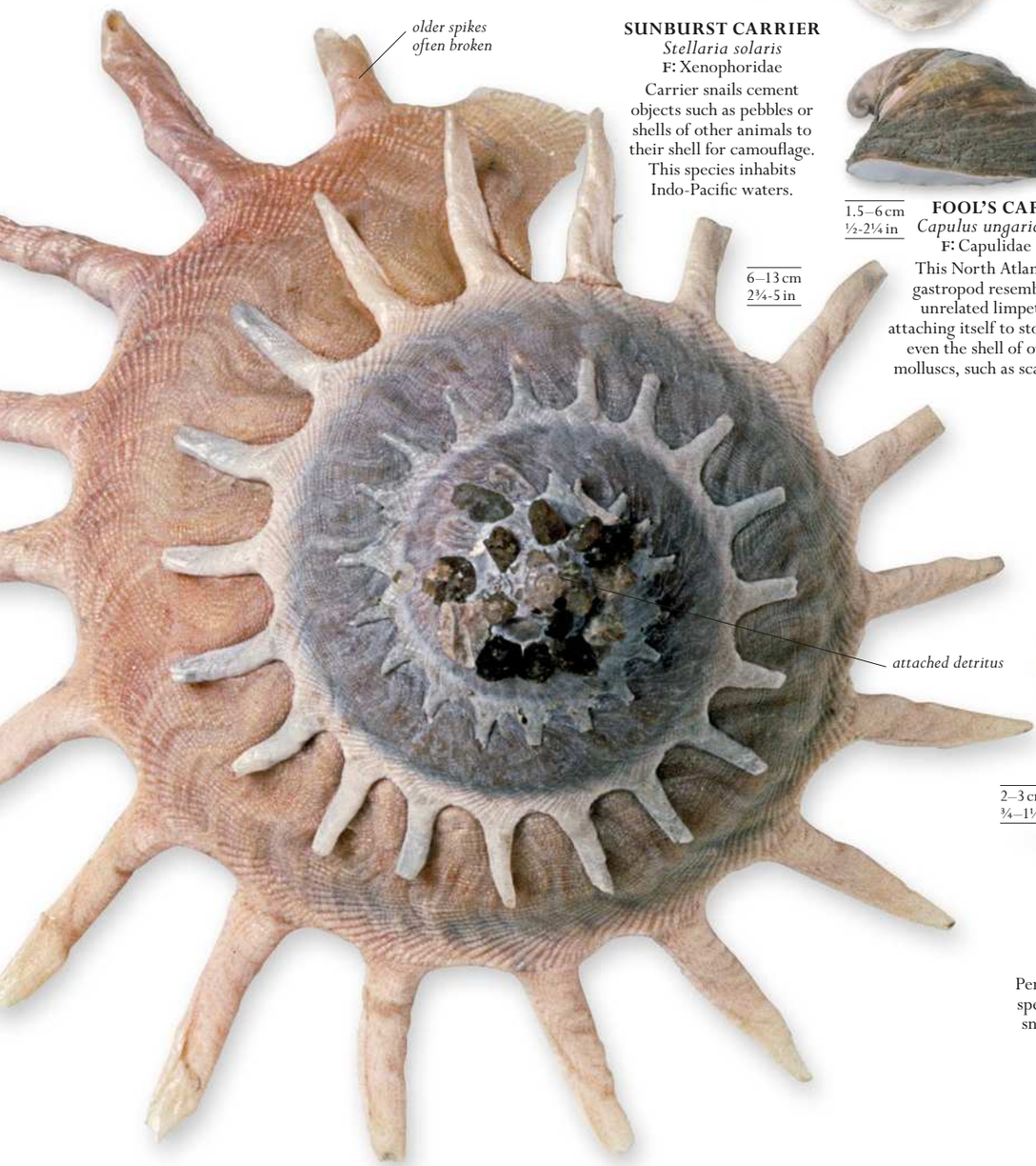
LARGE VIOLET SNAIL
Janthina janthina
F: Epitoniidae

Violet snails float in tropical waters, preying on floating cnidarians. They secrete mucus to create rafts of bubbles that keep them buoyed up.

10–15 cm
4–6 in

TIGER COWRIE
Cypraea tigris
F: Cypraeidae

The fleshy lobes of a cowrie's mantle wrap right around the smooth shell when it crawls. This Indo-Pacific species preys on other invertebrates.



SUNBURST CARRIER
Stellaria solaris
F: Xenophoridae

Carrier snails cement objects such as pebbles or shells of other animals to their shell for camouflage. This species inhabits Indo-Pacific waters.

6–13 cm
2¾–5 in

1.5–6 cm
½–2¼ in

FOOL'S CAP
Capulus ungaricus
F: Capulidae

This North Atlantic gastropod resembles unrelated limpets, attaching itself to stones or even the shell of other molluscs, such as scallops.

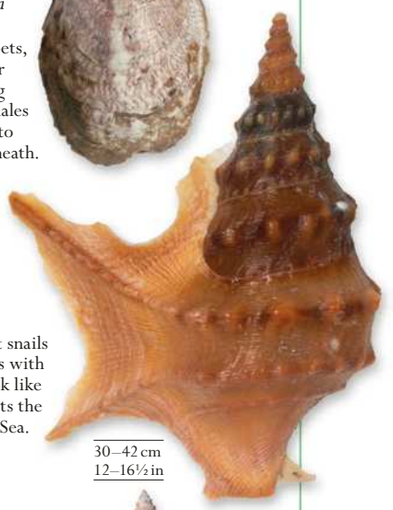
ATLANTIC SLIPPER LIMPET
Crepidula fornicata
F: Calyptraeidae

Unrelated to true limpets, filter-feeding slipper limpets form mating towers, with smaller males on top changing sex to replace dead females beneath.

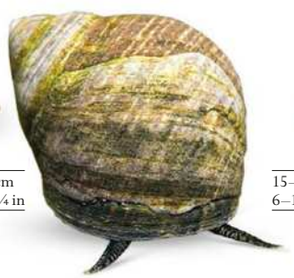
2–5 cm
¾–2 in

COMMON PELICAN'S FOOT
Aporrhais pespelecani
F: Aporrhaidiidae

Cousins of conches, pelican's foot snails are mud-dwelling detritus-eaters with extensions to their shell that look like webbed feet. This species inhabits the Mediterranean and the North Sea.



30–42 cm
12–16½ in



2–3 cm
¾–1¼ in

COMMON PERIWINKLE
Littorina littorea
F: Littorinidae

Periwinkles, such as this European species, form a family of intertidal snails with a globular spired shell closed by an operculum.

15–31 cm
6–12 in

PINK CONCH
Aliger gigas
F: Strombidae

Conches are mostly tropical, medium to large marine grazing snails. *Strombus* conches, such as this giant W. Atlantic species, have a flare-lipped shell.

»

» PERIWINKLES, WHELKS, AND RELATIVES

10–32 cm
4–12½ in

GIANT FROG SHELL
Tutufa bubo
F: Bursidae

Tropical marine frog shells are warty. This Indo-Pacific species eats bristleworms using a proboscis, first anaesthetizing them with saliva.

10–50 cm
4–20 in

TRUMPET TRITON
Charonia tritonis
F: Charoniidae

Tropical intertidal tritons and related frog and helmet shells are predators of other invertebrates. This Indo-Pacific species eats the coral-feeding crown-of-thorns starfish.

5 mm–3 cm
3/16–1¼ in

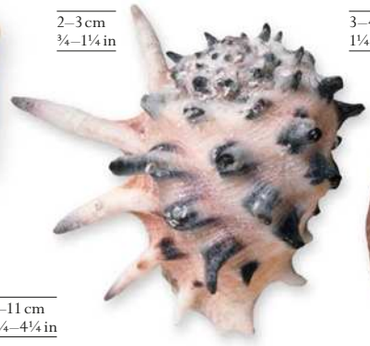
POLI'S NECKLACE SHELL
Euspira nitida
F: Naticidae

This is a European member of a family of sand-burrowing predators of bivalves. Necklace shells are named for their necklace-like ribbons of spawn.

8–11 cm
3¼–4¼ in

COMMON NORTHERN WHELK
Buccinum undatum
F: Buccinidae

A large predator of other molluscs and tube worms, this North Atlantic snail also consumes carrion, and is a popular seafood.



2–3 cm
¾–1¼ in

PRICKLY PACIFIC DRUPE
Drupa ricinus
F: Muricidae

A member of the dog whelk family, this snail lives on coral reefs of the Indo-Pacific, where it preys on bristle worms.

3–4 cm
1¼–1½ in

DOG WHELK
Nucella lapillus
F: Muricidae

This North Atlantic snail belongs to a whelk family that catch prey by using the radula to drill holes in the shells of barnacles and molluscs, helped by secretions of enzymes.

9–15 cm
3½–6 in

TEXTILE CONE
Conus textile
F: Conidae

Cone shells use their radula to harpoon their prey and inject venom. Some, such as this Indo-Pacific species, can be harmful to humans.

3–13 cm
1⅛–5 in

TENT OLIVE
Oliva porphyria
F: Olividae

The largest of the olive shells, this species from the Pacific coasts of Mexico and S. America has a colourful glossy shell.

7.5–11.5 cm
3–4½ in

BANDED TULIP
Cinctura lilium
F: Fasciolariidae

This is a Caribbean snail related to *Buccinum* whelks. Other sand-dwelling species with a longer siphonal canal are called spindle shells.

6–11 cm
2¼–4¼ in

IMPERIAL HARP
Harpa costata
F: Harpidae

Harp snails are sand-living predators of crabs, trapping them with their broad foot and digesting them with saliva. This is an Indian Ocean species.

7–20 cm
2¾–8 in

SUBULATE AUGER
Terebra subulata
F: Terebridae

Typical of many augers, this Indo-Pacific species has a patterned shell. Augers burrow through surface layers of sand to prey on worms.

FRESHWATER GILLED SNAILS

The Architaenioglossa are the only order of gilled snails containing no marine species. Most live in fresh water, but some live on land. Apple snails have gills in the mantle cavity that can function as a lung, allowing them to survive periods of drought. All species have an operculum, or trap door, for closing their shell.

10–15 cm
4–6 in

CHANNELLED APPLE SNAIL
Pomacea canaliculata
F: Ampullariidae

A typical apple snail, this tropical American species has been introduced elsewhere and has become an invasive pest.

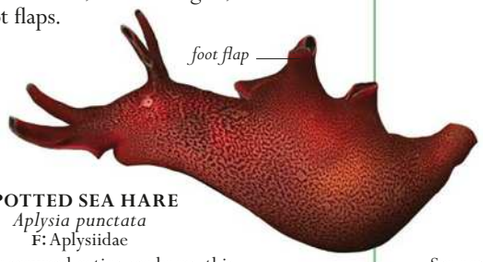
3–4 cm
1¼–1½ in

COMMON RIVER SNAIL
Viviparus viviparus
F: Viviparidae

A European freshwater snail with gills, this is a relative of the apple snails and, like them, has a trapdoor (operculum) to close its shell.

SEA HARES

Sensory water-tasting head stalks, a common feature of sea slugs, are so big in the large sea hares that they resemble ears. The Anaspidea have a small internal shell and, like sea angels, can swim with their foot flaps.

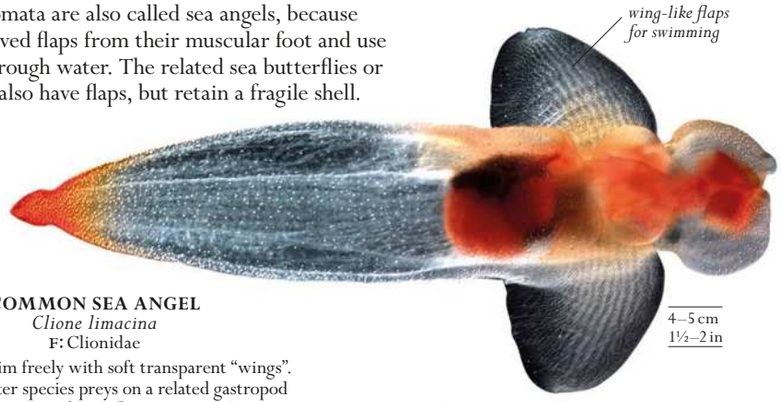


SPOTTED SEA HARE
Aplysia punctata
F: Aplysiidae

Like other seaweed-eating sea hares, this European species gathers in large breeding groups. As a defence, it releases ink when disturbed by predators.

SWIMMING SEA SLUGS

The Gymnosomata are also called sea angels, because they have evolved flaps from their muscular foot and use them to fly through water. The related sea butterflies or Thecosomata also have flaps, but retain a fragile shell.



COMMON SEA ANGEL
Clione limacina
F: Clionidae

Sea angels swim freely with soft transparent "wings". This cold-water species preys on a related gastropod called the Arctic sea butterfly (*Limacina helicina*).

TRUE SEA SLUGS

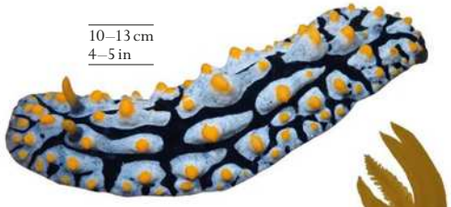
The Nudibranchia are the largest group of sea slugs. Nudibranch means "naked gills" and refers to the fact that these animals' gills are exposed on their back, rather than enclosed in a mantle cavity. Many species have vibrant colour patterns to advertise their toxicity.

BLACK-MARGINED SEA SLUG
Doriprismatica atromarginata
F: Chromodorididae

This common Indo-Pacific sea slug lives in shallow waters, feeding on sponges. It varies in colour from off-white to pale yellow.

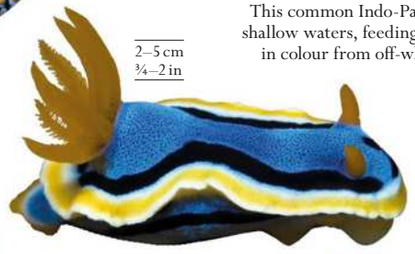
OPALESCENT SEA SLUG
Hermissenda crassicornis
F: Myrrhinidae

This intertidal northern Pacific species belongs to a group of sea slugs with body outgrowths that store the still potent stinging organs of their jellyfish prey.



VARICOSE SEA SLUG
Phyllidia varicosa
F: Phyllidiidae

This Indo-Pacific sea slug is a common inhabitant of rocks, rubble, and sand in coastal waters, where it preys on sponges.

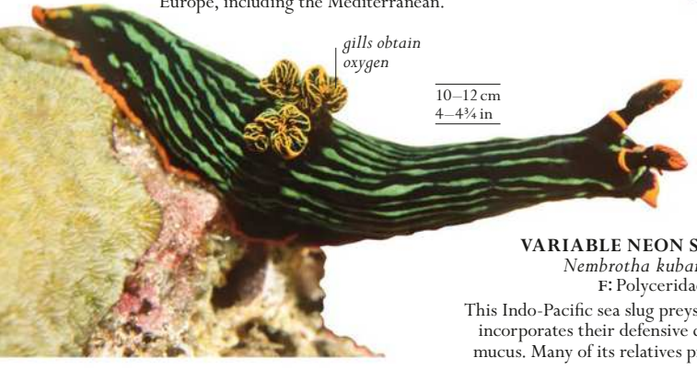


ANNA'S SEA SLUG
Chromodoris annae
F: Chromodorididae

Like other *Chromodoris* sea slugs, this variable species from the western Pacific Ocean specializes in feeding on sponges.

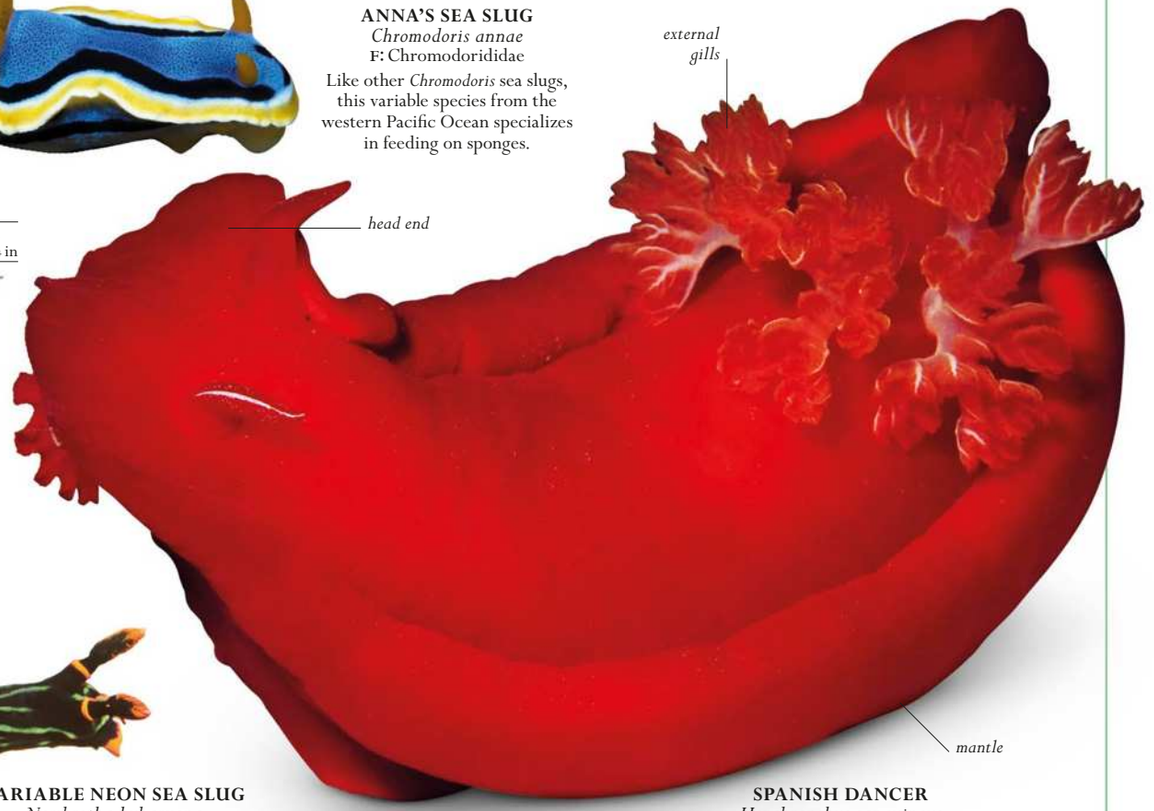
ELEGANT SEA SLUG
Okenia elegans
F: Goniodorididae

Typical of its family, this sea slug feeds on sea squirts. It occurs in waters around Europe, including the Mediterranean.



VARIABLE NEON SEA SLUG
Nembrotha kubaryana
F: Polyceridae

This Indo-Pacific sea slug preys on sea squirts and incorporates their defensive chemicals into its mucus. Many of its relatives prey on bryozoans.



SPANISH DANCER
Hexabranchus sanguineus
F: Hexabranchidae

A giant Indo-Pacific sea slug, this species gets its name from its free-swimming movements; its red mantle is said to resemble the ruffled skirt of a flamenco dancer.

FRESHWATER AIR-BREATHING SNAILS

Snails of the superorder Hygrophila have their mantle cavity developed as a lung; unlike most marine gastropods, they must return to the water surface to breathe. Mainly herbivorous, they are common in alkaline or neutral, weed-choked, stagnant or slow-moving fresh water.

EUROPEAN BLADDER SNAIL
Physella acuta
F: Physidae

Most snails have a shell that opens to the right (when the opening faces the observer), but members of the freshwater physid family have a left-opening shell.

GREAT POND SNAIL
Lymnaea stagnalis
F: Lymnaeidae

Widespread throughout temperate parts of the northern hemisphere, this is a common pond snail in still or slow-moving fresh water.

GREAT RAMSHORN SNAIL
Planorbarius corneus
F: Planorbidae

Ramshorn snails have a flat-coiled shell, instead of the spire shell typical of snails. Most – like this Eurasian species – occur in still, fresh water.

COMMON RIVER LIMPET
Ancylus fluviatilis
F: Planorbidae

Not a true limpet, but a limpet-like member of the ramshorn snail family, this species is common in fast-flowing European waters.

LAND AIR-BREATHING SNAILS AND SLUGS

The Stylommatophora are land snails and slugs that breathe air using a lung in their mantle cavity. They have eyes at the tips of their tentacles. Many are hermaphrodite and have both male and female reproductive organs. Their courtship behaviour involves the exchange of spear-like darts before mating.

GIANT AFRICAN SNAIL
Lissachatina fulica
F: Achatinidae

This giant land snail from E. Africa has been introduced to many other warm parts of the world, becoming an invasive pest.

CUBAN LAND SNAIL
Polymita picta
F: Cepolidae

This snail is found only in the mountain forests of Cuba. There are many varieties with different coloured shells.

BROWN GARDEN SNAIL
Cornu aspersum
F: Helicidae

This variably coloured species with a wrinkled shell is widespread in European woods, hedgerows, dunes, and gardens.

COMMON SHELLED SLUG
Testacella haliotidea
F: Testacellidae

A typical member of a family of slugs with a small external shell, this European species preys on earthworms.

DOMED DISC SNAIL
Discus patulus
F: Discidae

Discid snails make up a family characterized by certain primitive features and a flat, coiled shell. This is a N. American woodland species.

EUROPEAN BLACK SLUG
Arion ater
F: Arionidae

Black specimens of this European slug predominate in the north, but other individuals are orange. Although it eats plants, it also clears garden waste.

PACIFIC BANANA SLUG
Ariolimax columbianus
F: Ariolimacidae

Named for its yellow colour, the Pacific banana slug lives in wet coniferous forests on the western coast of N. America.

ROMAN SNAIL
Helix pomatia
F: Helicidae

Widespread in C. Europe on calcium-rich soils, this is the largest snail of the region and is bred locally for human consumption.

BROWN-LIPPED SNAIL
Cepaea nemoralis
F: Helicidae

A close relative of the Roman snail, this W. European species has a highly variable shell colour, and banding patterns for camouflage in different habitats.

ASHY-GREY SLUG
Limax cinereoniger
F: Limacidae

Keel-back slugs have a small internal shell. This large species of European woodland exists in a number of colour varieties.

CEPHALOPODS

Cephalopods are agile hunters in the mollusc phylum. Their sophisticated nervous system enables them to hunt down fast-moving prey.

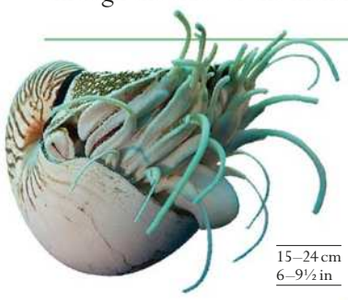
Cephalopods include the most intelligent of all invertebrates. Many species signal their mood using pigment-containing structures in their skin called chromatophores. The class is organized by number of arms. Squid and cuttlefish have eight arms used for swimming, plus two longer retractable arms, called tentacles, with suckers for gripping prey. Octopus lack tentacles, but have suckers on all eight of their arms. The cephalopod mantle encloses a cavity, which contains the gills. To obtain oxygen, cephalopods take in water through the sides of the mantle. It passes over the gills and is then expelled through a short funnel. Cephalopods can move backwards quickly by expelling water through the funnel, to propel themselves forwards. Squid, cuttlefish, and some octopus have fins on the sides of the mantle, used for open-water swimming. Most octopus spend their time on the sea floor.

Only the open-ocean nautilus has a coiled shell. In squid the shell is reduced to a pen-like structure that gives some internal support, in cuttlefish to a similar, calcified structure called a cuttlebone. Most species of octopus have lost their shell.

Cephalopods are fast-moving predators that use their arms to grasp prey, and a parrot-like beak to despatch it. Squid catch free-swimming prey, while cuttlefish and octopus take slower, bottom-crawling crustaceans, such as crabs.

PHYLUM	MOLLUSCA
CLASS	CEPHALOPODA
ORDERS	9
FAMILIES	About 50
SPECIES	822

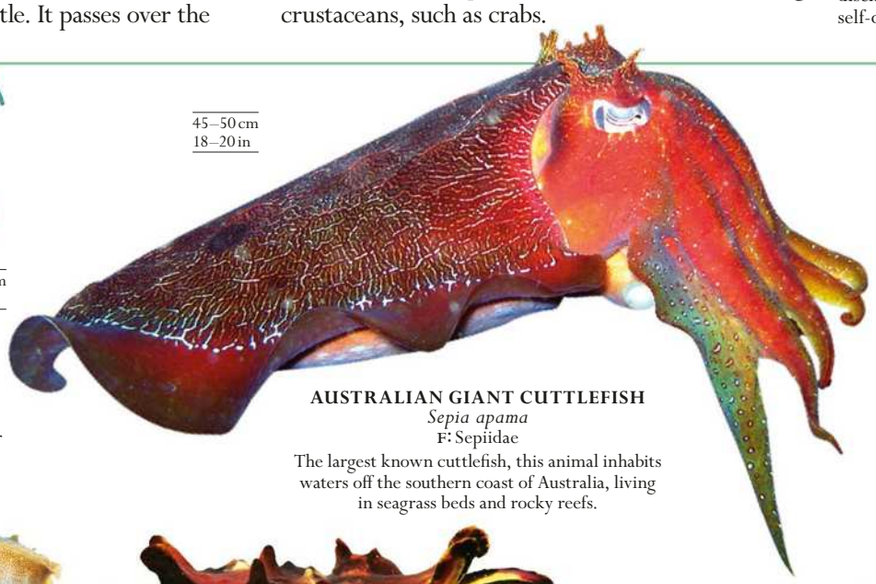
A North Pacific giant octopus discharges black-pigmented ink in self-defence as it jets away from a predator.



15–24 cm
6–9½ in

CHAMBERED NAUTILUS
Nautilus pompilius
F: Nautilidae

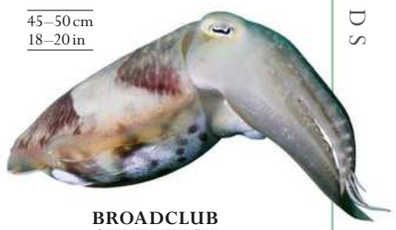
This Indo-Pacific species is the largest and best-known living member of a small group of cephalopods otherwise known only as fossils.



45–50 cm
18–20 in

AUSTRALIAN GIANT CUTTLEFISH
Sepia apama
F: Sepiidae

The largest known cuttlefish, this animal inhabits waters off the southern coast of Australia, living in seagrass beds and rocky reefs.



45–50 cm
18–20 in

BROADCLUB CUTTLEFISH
Sepia latimanus
F: Sepiidae

This large cuttlefish is wide-ranging throughout the Indo-Pacific region. It is an abundant predator on coral reefs, feeding on prawns and shrimps.

40–50 cm
16–20 in

COMMON CUTTLEFISH
Sepia officinalis
F: Sepiidae

Like many other cuttlefish, this species migrates inshore to spawn on muddy sediments. It occurs off the coasts of Europe and South Africa.

6–7 cm
2¼–2¾ in

FLAMBOYANT CUTTLEFISH
Metasepia pfefferi
F: Sepiidae

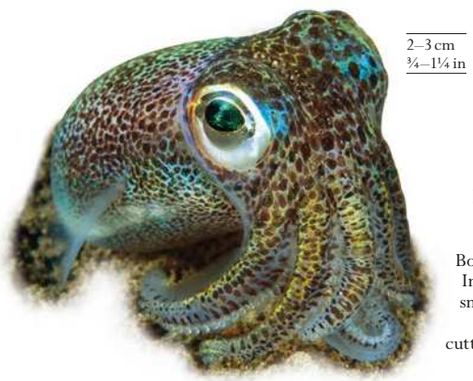
Unusual among cuttlefish for its habit of using its tentacles to walk on ocean floors, this Indo-Pacific cuttlefish has recently been shown to be poisonous.

20–50 cm
8–20 in

prey-snatching tentacles

WHIP-LASH SQUID
Mastigoteuthis sp.
F: Mastigoteuthidae

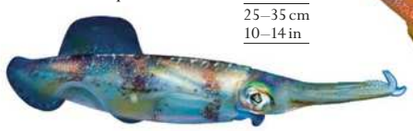
Reddish whip-lash squid such as this species hover with broad fins in deep water, waiting for prey with its long tentacles extended.



2–3 cm
¾–1¼ in

BERRY'S BOBTAIL SQUID
Euprymna berryi
F: Sepiolidae

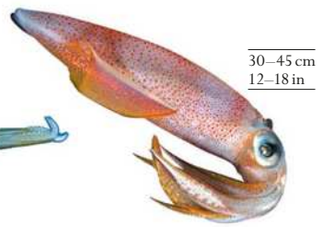
Bobtail squid, such as this Indo-Pacific species, are small cuttlefish relatives. They have a pen, not cuttlebone, and the rounded body has lobed fins.



25–35 cm
10–14 in

BIGFIN REEF SQUID
Sepioteuthis lessoniana
F: Loliginidae

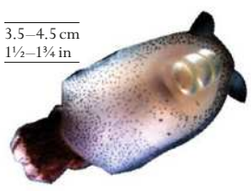
A pair of large fins makes this Indo-Pacific squid resemble a cuttlefish. It communicates by flashing light from special organs, which contain light-emitting bacteria.



30–45 cm
12–18 in

COMMON SQUID
Loligo vulgaris
F: Loliginidae

This commercially important squid is common in the N.E. Atlantic and Mediterranean. Like related species, it has prominent side fins.



3.5–4.5 cm
1½–1¾ in

RAM'S HORN SQUID
Spirula spirula
F: Spirulidae

This small, deep-ocean cephalopod contains a spiral gas-filled shell that acts as a float; the animal rises towards the ocean surface at night.

»

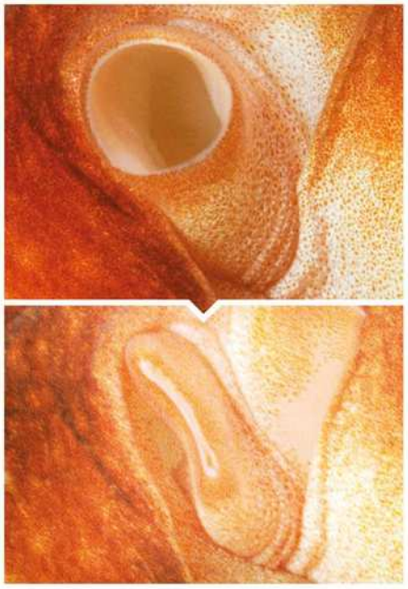
COMMON OCTOPUS
Octopus vulgaris

Whether it is extricating a lobster from a lobster pot or hunting a scuttling crab, the common octopus is one of the most intelligent of all the invertebrates. This sea-living mollusc has excellent vision and eight grasping arms, or tentacles, which are also used for crawling. The octopus can change colour in an instant and squeeze through very narrow crevices. And its horny beak can bite into prey, whose scattered shell fragments frequently litter the sand around its lair. But in spite of its versatility, the common octopus is short-lived. Upon hatching, an infant octopus enters the oceanic plankton with half a million of its siblings, before descending to the seabed two months later. If it survives being eaten, it takes little more than a year to mature and spawn its own offspring before dying. The common octopus is widespread in tropical and warm temperate oceanic waters, and may consist of several similar species.

SIZE Tentacle span 1.5–3 m (5–10 ft)
HABITAT Rocky coastal waters
DISTRIBUTION Widespread in tropical and warm temperate waters
DIET Crustaceans, shelled molluscs

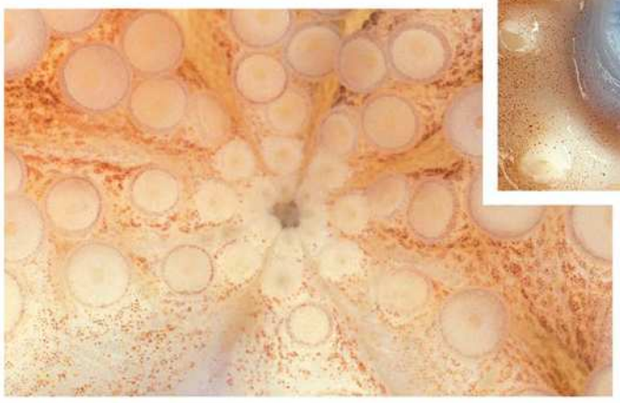
fleshy mantle encloses a cavity that contains vital organs, including gills for breathing

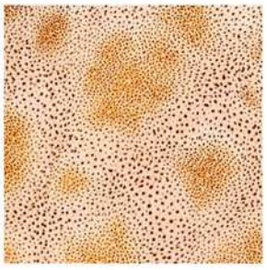
> INTELLIGENT MOLLUSC
An octopus is an agile predator with an advanced nervous system. Two-thirds of its neurons are located in its arms, which operate with a remarkable degree of independence from its brain. Experiments show that it also has considerable problem-solving intelligence, and excellent long- and short-term memory.



^ FUNNEL, OPEN AND CLOSED
On one side of the mantle, just behind the head, is a funnel, which the octopus uses in three ways: to expel water after gills have extracted oxygen; to rapidly discharge water as jet propulsion for a quick getaway; and to squirt a confusing cloud of ink at the enemy before fleeing.

v UNDERSIDE
The octopus is a cephalopod, which literally means "head-footed". Its eight mobile arms radiate from the underside of the head, where the mouth can be seen at the centre.





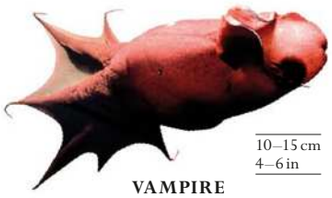
< SKIN
The skin contains special cells called chromatophores. These contain pigment which can change the octopus's colour – to blend in with its surroundings or to signal its mood if angry or afraid.

< BEAK
This octopus is a predator of crustaceans, among other prey. Its jaws are a parrot-like beak, which is strong enough to penetrate the tough carapace of a crab or lobster.

^ SUCKER
Each arm has two series of suckers. These give the octopus an excellent grip, allowing it to negotiate the sea bottom and coral reefs with ease. The suckers also have receptors that enable the octopus to taste what it is touching.

prominent eye with a horizontal, slit-shaped pupil
tough, warty skin can change colour, texture, and shape for camouflage
long, muscular arms for moving over the seabed and grasping objects
cup-like suckers

» CEPHALOPODS



10–15 cm
4–6 in

VAMPIRE SQUID
Vampyroteuthis infernalis
F: Vampyroteuthidae

This deep-sea cephalopod – with characteristics seemingly intermediate between squid and octopus – has fins projecting from its mantle and light-producing organs covering the body.

20 cm
8 in

DUMBO OCTOPUS
Grimpoteuthis plena
F: Opisthoteuthidae

Named for its ear-like fins used in swimming, this cephalopod lives at depths of 3–4,000 m (10–13,000 ft), preying on other invertebrates.

3–6 cm
1¼–2¼ in

WINGED ARGONAUT
Argonauta hians
F: Argonautidae

Argonauts – also known as paper nautiluses – are octopus relatives. Females produce a paper-thin egg-case that resembles a shell. This species is distributed widely around the world.

2 m
6½ ft

NORTH PACIFIC GIANT OCTOPUS
Enteroctopus dofleini
F: Enteroctopodidae

Perhaps the largest of all octopuses, this animal is surprisingly short-lived. Females are diligent carers of their huge broods.

5 cm
2 in

PACIFIC LONG-ARMED OCTOPUS
Octopus sp.
F: Octopodidae

One of several octopuses with especially long arms, adults of this species frequent sandy lagoons, but translucent juveniles live among oceanic plankton.

1–1.5 m
39–59 in

CARIBBEAN REEF OCTOPUS
Octopus briareus
F: Octopodidae

An octopus of the W. Atlantic and Caribbean, this coral-dwelling species often traps its prey by spreading its webbed arms like a net.

1.5–3m
5–10 ft

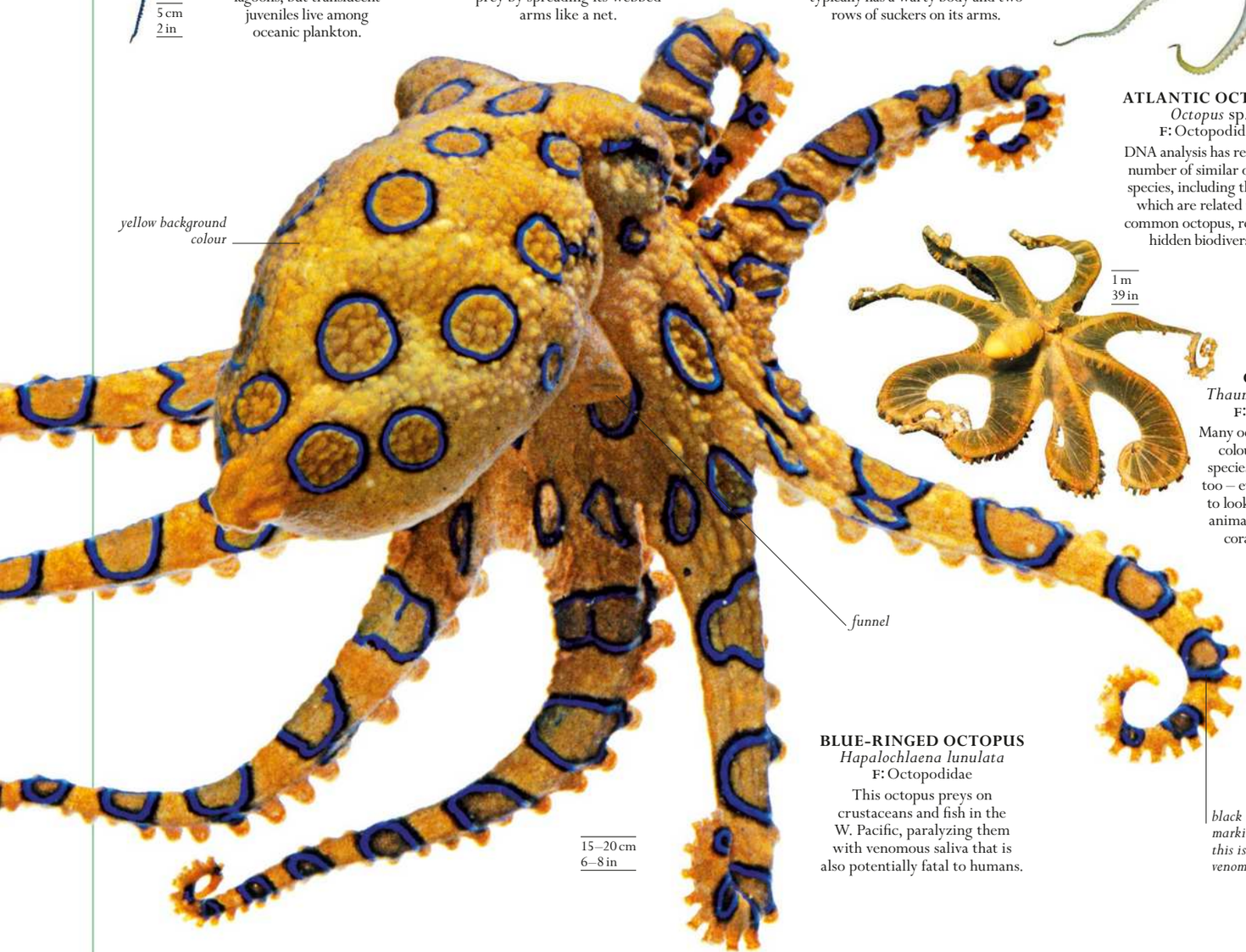
COMMON OCTOPUS
Octopus vulgaris
F: Octopodidae

Globally widespread in tropical and warm temperate waters, this octopus typically has a warty body and two rows of suckers on its arms.

50–70 cm
20–28 in

ATLANTIC OCTOPUS
Octopus sp.
F: Octopodidae

DNA analysis has revealed a number of similar octopus species, including this one, which are related to the common octopus, revealing hidden biodiversity.



15–20 cm
6–8 in

BLUE-RINGED OCTOPUS
Hapalochlaena lunulata
F: Octopodidae

This octopus preys on crustaceans and fish in the W. Pacific, paralyzing them with venomous saliva that is also potentially fatal to humans.

black and blue ring markings warn that this is a highly venomous species

1 m
39 in

MIMIC OCTOPUS
Thaumoctopus mimicus
F: Octopodidae

Many octopuses can change colour, but this Asian species can change shape too – even disguising itself to look like other marine animals such as sponges, corals, and jellyfish.

CHITONS

Flattened, rock-hugging chitons are among the most primitive of molluscs. Most are grazers of algae and microbe films, and occur in coastal waters.

A chiton's shell, popularly known as a "coat-of-mail" shell, is made up of eight interlocking plates that are sufficiently flexible to allow the animal to bend when gliding over uneven rocks – or even to roll up when disturbed. Chitons have no eyes or tentacles, although the shell itself contains cells that enable them to react to light. The plates are fringed by the edge of the mantle, known as the girdle. The mantle forms a fleshy skirt around the chiton. This overhangs grooves running down each side of the animal, which channel water, delivering oxygen to gills that project into the grooves. The radula, or rasping tongue, is coated with minute teeth reinforced with iron and silica, so chitons can graze on the toughest encrusting algae.

PHYLUM	MOLLUSCA
CLASS	POLYPLACOPHORA
ORDERS	2
FAMILIES	20
SPECIES	1,026

8 cm/3¼ in

MARBLED CHITON
Chiton marmoratus
F: Chitonidae
Like other chitons, the shell plates of this Caribbean mollusc are composed entirely of a chalky mineral called aragonite.

4–5 cm/1½–2 in

GREEN CHITON
Chiton glaucus
F: Chitonidae
A variable-coloured chiton, this species occurs along the coastlines of New Zealand and Tasmania and, like most chitons, is active at night.

2–8 cm/¾–3¼ in

WEST INDIAN FUZZY CHITON
Acanthopleura granulata
F: Chitonidae
This spiky-fringed Caribbean chiton can tolerate exposure to sun, and can live high up in the intertidal zone.

2.5 cm/1 in

DECKED CHITON
Ischnochiton comptus
F: Ischnochitonidae
Ischnochiton chitons have a spiny or scaly girdle fringe. This is a common intertidal species of W. Pacific shores.

30–33 cm
12–13 in

5–8 cm
2–3¼ in

GUMBOOT CHITON
Cryptochiton stelleri
F: Acanthochitonidae
In one chiton family the fleshy girdle overlaps the chain mail plates. In this North Pacific species, the largest chiton, it forms a leathery skin.

BRISTLED CHITON
Mopalia ciliata
F: Mopaliidae
Named for its prominent hairy girdle, this chiton of the Pacific coast of N. America is sometimes found beneath long-moored boats.

4–7 cm
1½–2¾ in

HAIRY CHITON
Chaetopleura papilio
F: Chaetopleuridae
A bristly-girdled species with brown-striped chainmail plates, the hairy chiton is found beneath rocks on South African coasts.

4–5 cm
½–2 in

LINED CHITON
Tonicella lineata
F: Ischnochitonidae
This brightly coloured chiton occurs on North Pacific coasts, where it may be camouflaged when feeding on red encrusting algae.

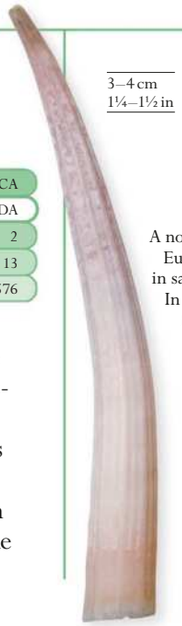
TUSK SHELLS

Curious, mud-shovelling tusk shells live in marine sediments and have a tubular curved shell – open at both ends and unlike the shell of any other mollusc.

PHYLUM	MOLLUSCA
CLASS	SCAPHOPODA
ORDERS	2
FAMILIES	13
SPECIES	576

Tusk shells are common, but are rarely seen because they usually occur far offshore, with the wide base of the hollow tusk buried in mud. The eyeless head and foot reach deeper into the sediment, probing for food with their tentacle-like structures called captacula, and tasting the mud with chemical detectors. When food is found – small invertebrates or detritus – the tentacles bring it to the mouth, where it is ground up by the radula, a rasping tongue typical of molluscs. Tusk shells lack gills; the animal's fleshy mantle encloses a water-filled, oxygen-extracting tube that runs the length of the shell. When levels of oxygen run low, the tusk shell contracts its foot and squirts the stale water out through the top end of the shell. Fresh water enters by the same route.

3–4 cm
1¼–1½ in



EUROPEAN TUSK
Antalis dentalis
F: Dentaliidae
A northeast Atlantic species, the European tusk is widespread in sandy areas of coastal waters. In places its empty shells are found in huge numbers.

5–8 cm
2–3¼ in

BEAUTIFUL TUSK
Pictodentalium formosum
F: Dentaliidae
This colourful tropical tusk shell has been recorded in marine sediments in Japan, the Philippines, Australasia, and New Caledonia.

ECHINODERMS

Echinoderms include an astonishing array of sea creatures, ranging from filter-feeding feather stars to grazing urchins and predatory starfish.

This is the only large invertebrate phylum entirely restricted to salt water. Echinoderms are sluggish, slow-moving inhabitants of the sea floor and most have a body form built around a five-part radial symmetry. Echinoderm means "spiny-skinned" – a reference to the hard, calcified structures, called ossicles, that make up the internal skeleton of these animals. In starfish these are spaced out within the soft tissue so that the animal is reasonably flexible, but in urchins they are fused together to form a solid internal shell. In sea cucumbers the ossicles are so minute and sparsely distributed – or even absent – that the entire animal is soft-bodied.

HYDRAULIC FEET

Echinoderms are the only animals with a water transport system. Sea water is drawn into the centre of the body through a perforated, sieve-like plate, usually on the upper surface of the body. The water circulates through tubes that run through the animal and is forced into tiny soft projections near the surface, called tube feet, which can move back and forth and stick to surfaces. In feather stars these tube feet point upwards on the feathery arms, capturing particles of food, which are then moved towards the central mouth. In other echinoderms thousands of downward-pointing tube feet are used in locomotion – together they pull the animal over sediment and rock.

DEFENCE

The tough prickly skin of most echinoderms offers good protection from potential predators, but these animals defend themselves in other ways too. Many urchins are also covered with formidable spines; some can inflict serious wounds in humans. Many species have tiny pincer-like projections, sometimes venomous, that can remove cluttering debris as well as deter potential predators. Soft-bodied sea cucumbers rely on noxious chemicals to protect them – and are often brightly coloured as a warning. As a last resort, some sea cucumbers can even spew out sticky tangles or eject their gut.

PHYLUM	ECHINODERMATA
CLASSES	5
ORDERS	35
FAMILIES	173
SPECIES	7,447

The tiny tube feet on which echinoderms move around the seabed are seen here on a crown-of-thorns starfish, *Acanthaster planci*.

FEATHER STARS

A feather star carries five basic filter-feeding arms, which in some species branch into a dense cluster. A mouth and anus point upwards from the centre of the star. Some members of the class Crinoidea crawl along on their feather-like arms. Others, known as sea lilies, are attached by a stalk.

10–15 cm
4–6 in

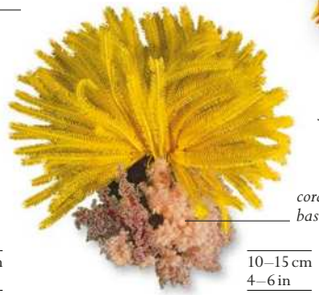
PRETTY FEATHER STAR
Cenometra emendatrix
F: Colobometridae

The arms of a feather star are fringed with smaller branches called pinnules that catch particles of food more effectively. In this tropical Pacific species they are white.

10–20 cm
4–8 in

GOLDEN FEATHER STAR
Davidaster rubiginosus
F: Comatulidae

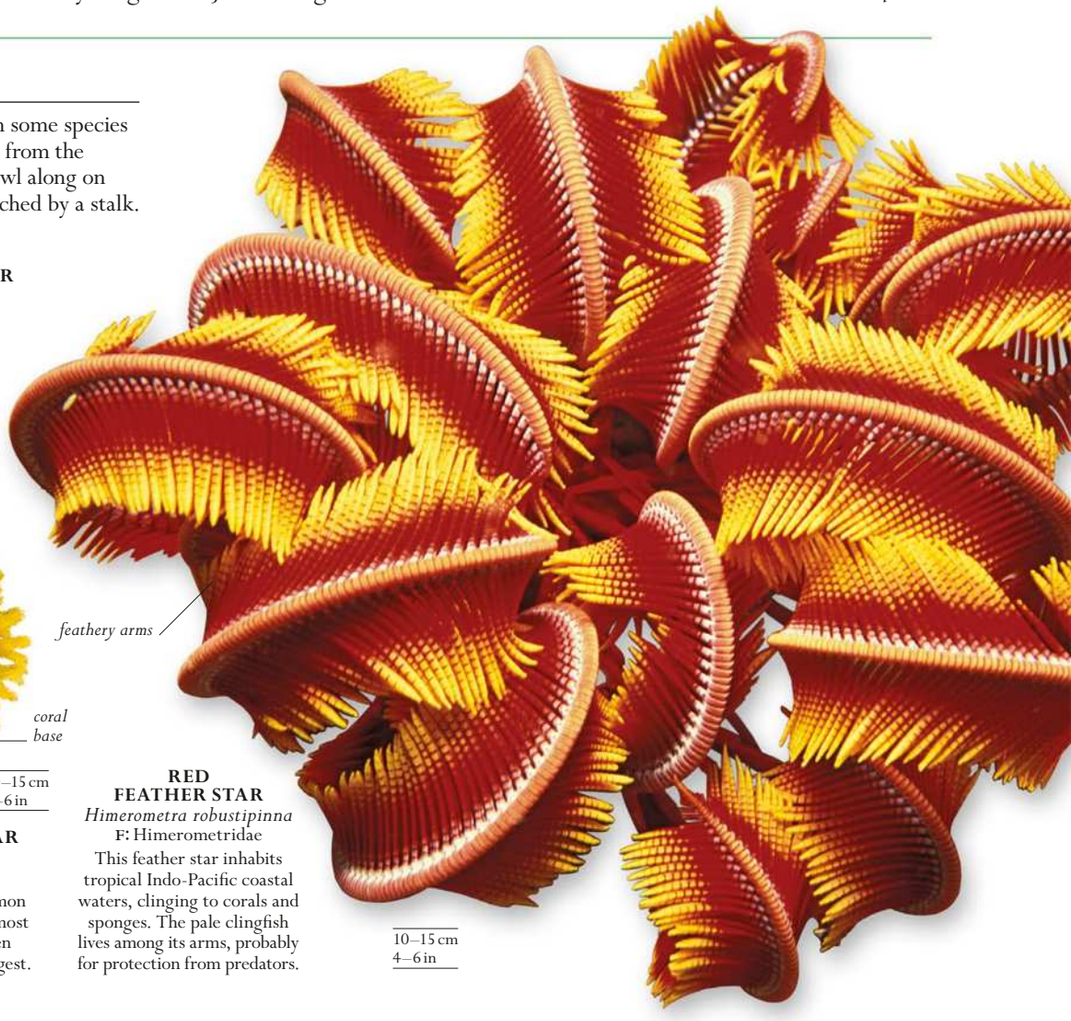
Like other crinoids, this species from the W. Atlantic, is a suspension feeder, catching plankton with its feathery arms.



10–15 cm
4–6 in

YELLOW FEATHER STAR
Anneissia bennetti
F: Comasteridae

Like many crinoids, this common W. Pacific species filter feeds most voraciously at night and when underwater currents are strongest.



10–15 cm
4–6 in

RED FEATHER STAR
Himerometra robustipinna
F: Himerometridae

This feather star inhabits tropical Indo-Pacific coastal waters, clinging to corals and sponges. The pale clingfish lives among its arms, probably for protection from predators.

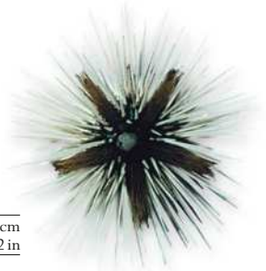
URCHINS AND RELATIVES

Sea urchins, which belong to the class Echinoidea, gave their name to the whole phylum. The hard ossicles of an urchin are plates that interlock to form a shell called a test. The animal's spines help in locomotion and defence. The mouth generally faces downwards and the anus upwards – with rows of tube feet running between the two.

10–11 cm
4–4¼ in

INDO-PACIFIC SAND DOLLAR
Sculpsitechinus auritus
F: Astriclypeidae

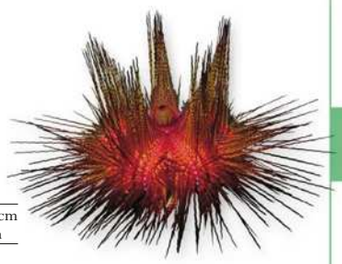
This Indo-Pacific urchin of coastal sands is a typical member of a group of burrowing sea dollars, named for their flattened appearance.



4–5 cm
1½–2 in

BANDED SEA URCHIN
Echinothrix calamaris
F: Diadematidae

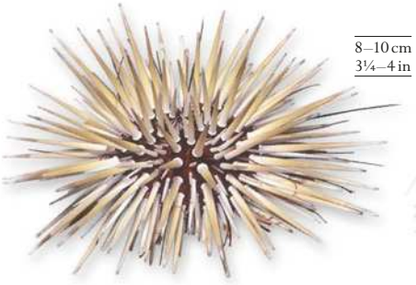
The shorter spines of this Indo-Pacific reef-dwelling urchin are painfully venomous. Cardinalfish (Apogonidae) often hide among them for protection.



20 cm
8 in

RED URCHIN
Astropyga radiata
F: Diadematidae

This Indo-Pacific lagoon species belongs to a family of tropical urchins with long hollow spines. It is often carried by a crab, *Dorippe frascone*.



8–10 cm
3¼–4 in

MATHA'S URCHIN
Echinometra mathaei
F: Echinometridae

This Indo-Pacific species belongs to a group of urchins characterized by thick spines. It lives in crevices on coral reefs.

16–18 cm
6½–7 in

EDIBLE URCHIN
Echinus esculentus
F: Echinidae

This large globular urchin common on N.E. Atlantic coasts has a variable colour. It grazes on invertebrates and algae, especially kelp.

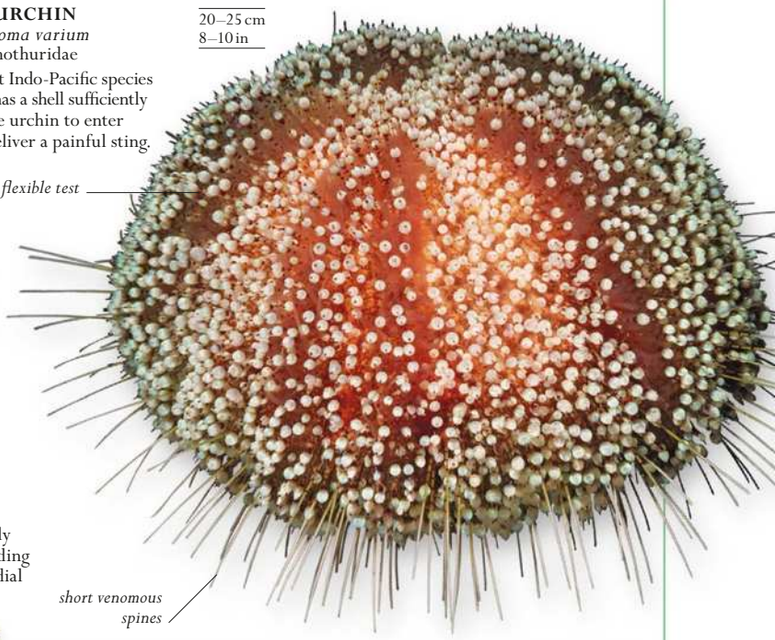
FIRE URCHIN
Asthenosoma varium
F: Echinothuridae

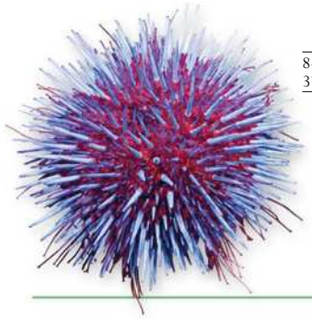
This somewhat flat Indo-Pacific species of sandy lagoons has a shell sufficiently flexible for the urchin to enter crevices. It can deliver a painful sting.

7–8 cm
2¾–3¼ in

SEA POTATO
Echinocardium cordatum
F: Loveniidae

Heart urchins, such as this globally widespread species, are detritus-feeding burrowers that lack the obvious radial symmetry of other urchins.





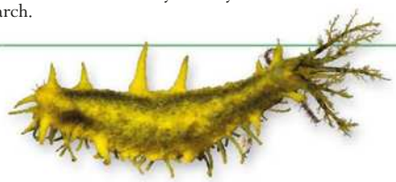
8–10 cm
3¼–4 in

PURPLE URCHIN
Strongylocentrotus purpuratus
F: Strongylocentrotidae

An inhabitant of the underwater kelp forests along the Pacific coast of N. America, this urchin is often used in biomedical research.

SEA CUCUMBERS

Sea cucumbers are soft tubular animals, with a mouth surrounded by a ring of food-collecting tentacles at one end, and an anus at the other. Some Holothuroidea shovel or burrow in sediments using their tentacles; others use rows of tube feet to crawl along the seabed.



5–8 cm
2–3¼ in

YELLOW SEA CUCUMBER
Colochirus robustus
F: Cucumariidae

This echinoderm belongs to a family of thick-skinned sea cucumbers. Like this Indo-Pacific species, many are covered in knobbly projections.

SEA APPLE CUCUMBER
Pseudocolochirus violaceus
F: Cucumariidae

Sea apples are brightly coloured, highly poisonous, reef-dwelling sea cucumbers. This species has yellow or orange tube feet, but variable body colour.

25–30 cm
10–12 in

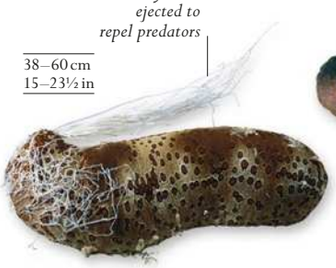
EDIBLE SEA CUCUMBER
Holothuria (Halodeima) edulis
F: Holothuriidae

Large sea cucumbers are especially abundant in tropical waters. This Indo-Pacific species is harvested and dried for human consumption.

60 cm
23½ in

VERMIFORM SEA CUCUMBER
Synapta maculata
F: Synaptidae

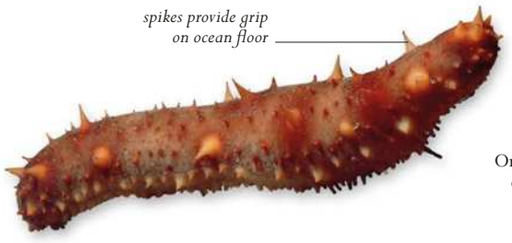
Typical of its family, this Indo-Pacific species is a soft-bodied, worm-like sea cucumber that burrows in soft sediment. It lacks tube feet.



38–60 cm
15–23½ in

OCELLATED SEA CUCUMBER
Bohadschia argus
F: Holothuriidae

Distributed from the W. Indian Ocean around Madagascar to the South Pacific, this large species is variable in colour, but is always spotted.



35–40 cm
14–16 in

GIANT CALIFORNIA SEA CUCUMBER
Apostichopus californicus
F: Stichopodidae

One of the largest sea cucumbers of N. America's Pacific coast, this fleshy spiked species is fished as a local delicacy.

60–75 cm
23½–30 in

PRICKLY REDFISH
Thelenota ananas
F: Stichopodidae

This echinoderm belongs to a family of sea cucumbers covered in fleshy spikes. It occurs on sandy seabeds around Indo-Pacific coral reefs.

30 cm
12 in

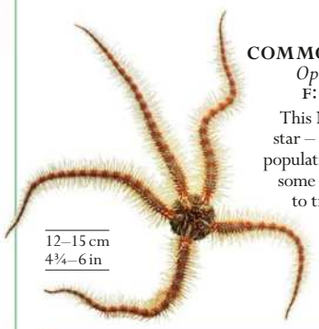
DEEP SEA CUCUMBER
Kolga hyalina
F: Elpidiidae

Virtually worldwide in distribution at depths of up to 1,500 m (5,000 ft), this is one of many little-known sea cucumbers found on ocean floors.

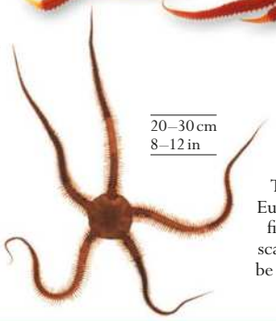
BRITTLE STARS

These animals are named for the fact that their long, thin, sometimes branching, arms easily break off. There is one opening to the gut in the central disc – a downward-facing mouth. Some Ophiuroidea use their arms to trap food particles; others are predatory.

SHORT-SPINED BRITTLE STAR
Ophioderma sp.
F: Ophiodermatidae
A brittle star of W. Atlantic coastal waters, this species lives in submerged grass beds, where it preys on other invertebrates, such as shrimp.



COMMON BRITTLE STAR
Ophiothrix fragilis
F: Ophiotrichidae
This N.E. Atlantic brittle star – often found in dense populations – has spiny arms, some of which it holds up to trap food particles.

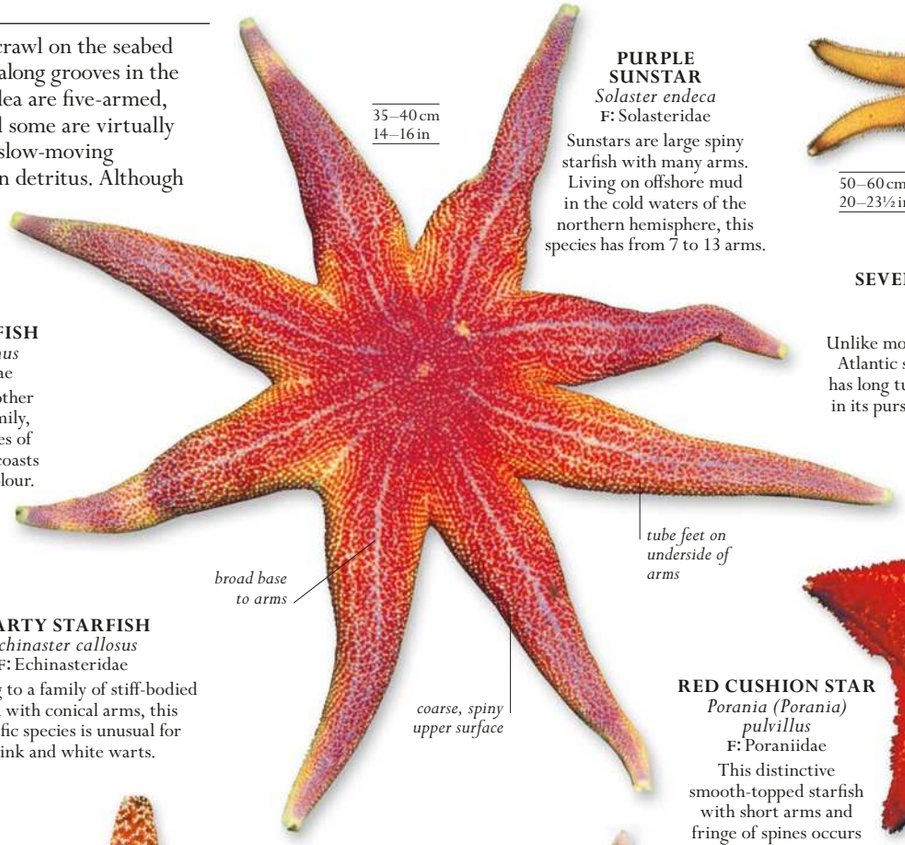


BLACK BRITTLE STAR
Ophiocomina nigra
F: Ophiocomidae
This large brittle star of European waters can either filter feed on particles or scavenge on detritus. It can be common on rocky coasts with strong currents.

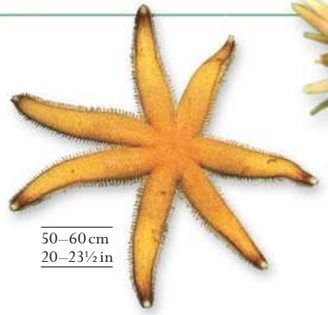
GORGON'S HEAD BRITTLE STAR
Gorgonocephalus caputmedusae
F: Gorgonocephalidae
This species, named for its coiled, snake-like branching arms, is common around European coasts. Larger animals are found in places of strong currents, where they can collect more food.

STARFISH

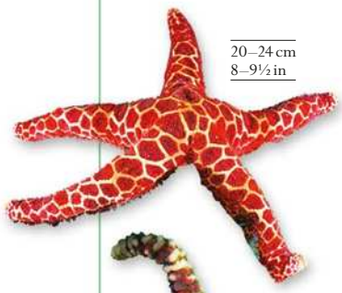
Like most other echinoderms, starfish crawl on the seabed using their rows of tube feet. These run along grooves in the starfish's arms. Most species of Asteroidea are five-armed, but a few have more than five arms, and some are virtually spherical in shape. Many prey on other slow-moving invertebrates; others scavenge or feed on detritus. Although their skin is studded with hard ossicles, starfish are sufficiently flexible to catch prey.



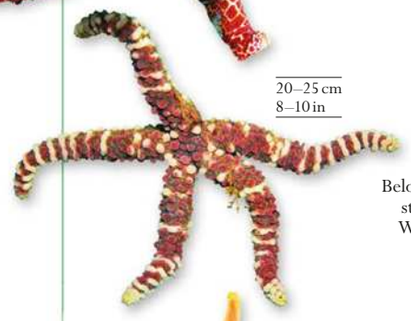
PURPLE SUNSTAR
Solaster endeca
F: Solasteridae
Sunstars are large spiny starfish with many arms. Living on offshore mud in the cold waters of the northern hemisphere, this species has from 7 to 13 arms.



SEVEN ARM STARFISH
Luidia ciliaris
F: Luidiidae
Unlike most other starfish, this large Atlantic species has seven arms. It has long tube feet and is fast moving in its pursuit of other echinoderms.

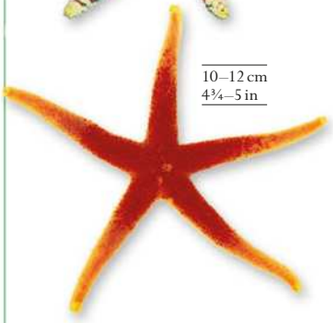


MOSAIC STARFISH
Plectaster decanus
F: Echinasteridae
Like a number of other members of its family, this striking species of S.W. Pacific rocky coasts varies greatly in colour.



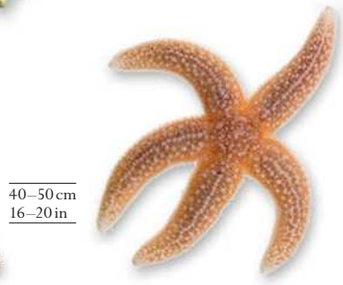
WARTY STARFISH
Echinaster callosus
F: Echinasteridae
Belonging to a family of stiff-bodied starfish with conical arms, this W. Pacific species is unusual for its pink and white warts.

RED CUSHION STAR
Porania (Porania) pulvillus
F: Poraniidae
This distinctive smooth-topped starfish with short arms and fringe of spines occurs on European rocky coasts, often on kelp holdfasts.



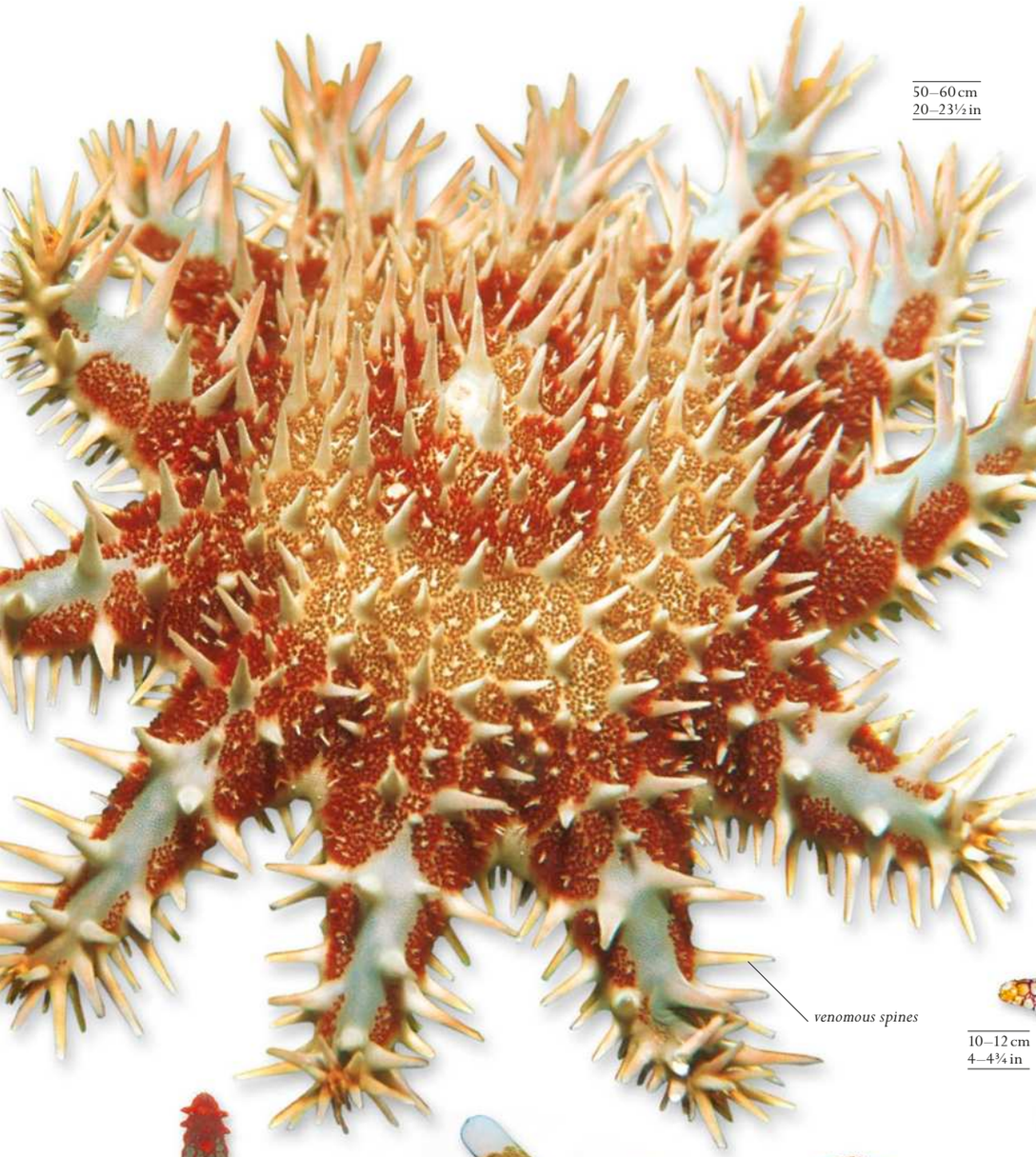
BLOOD HENRY STARFISH
Henricia oculata
F: Echinasteridae
This relative of the warty starfish lives in tidal pools and kelp forests of the N.E. Atlantic. Its body secretes mucus to trap food particles.

OCHRE STARFISH
Pisaster ochraceus
F: Asteriidae
This N. American Pacific relative of the common Atlantic starfish – like others of its family – hunts invertebrates. It is an important predator of mussels.



COMMON STARFISH
Asterias rubens
F: Asteriidae
This common N.E. Atlantic predator of other invertebrates is unusual among echinoderms in tolerating estuarine conditions. It often occurs in huge local populations.

GIANT SUNFLOWER STARFISH
Pycnopodia helianthoides
F: Asteriidae
One of the world's largest starfish, this many-armed species preys on molluscs and other echinoderms. It lives among offshore seaweed on the N.E. Pacific coast.



50–60 cm
20–23½ in

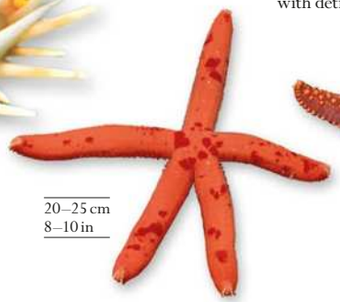
CROWN-OF-THORNS STARFISH
Acanthaster planci
F: Acanthasteridae

This giant Indo-Pacific starfish is a predator of coral polyps, threatening some reef ecosystems. It has 10–20 arms and sharp, mildly venomous spines that can cause injury to humans.

20–30 cm
8–12 in

BLUE STARFISH
Linckia laevigata
F: Ophidiasteridae

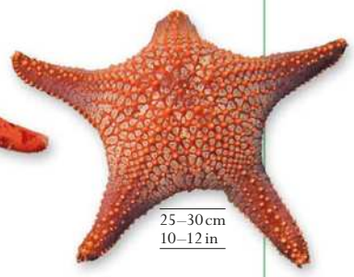
Snake-armed starfish have a smooth, spineless surface. This Indo-Pacific species is usually blue, but a minority are purple or orange. It frequently lives in association with detritus-eating shrimp.



20–25 cm
8–10 in

PURPLE STARFISH
Ophidiaster ophidianus
F: Ophidiasteridae

This snake-armed starfish occurs in warmer waters of the northeast Atlantic, on coarse seabeds around the Mediterranean and as far as W. Africa.



25–30 cm
10–12 in

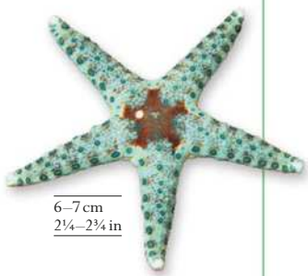
KNOBBLY STARFISH
Pentaceraster cumingi
F: Oreasteridae

This large strikingly patterned cushion star occurs on sandy and rubble-strewn sea bottoms of tropical central and E. Pacific.

10–12 cm
4–4¾ in

NECKLACE STARFISH
Fromia monilis
F: Goniasteridae

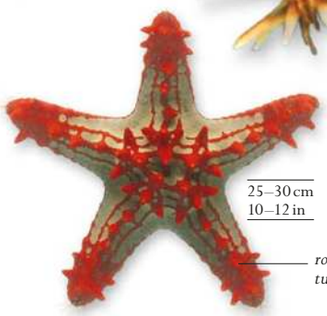
There are 15 *Fromia* species, sometimes difficult to tell apart, but all are brightly coloured to deter predators. This common shallow-water species is widespread in the Indo-Pacific.



6–7 cm
2¼–2¾ in

CUMING'S PLATED STARFISH
Neoferdina cumingi
F: Goniasteridae

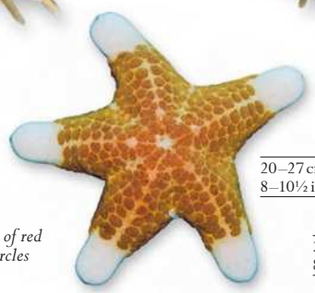
This Pacific species lives on shallow reefs but others in the family occur at depths below 1,000m (3,300ft). All are characterized by rows of granular plates on their upper surface.



25–30 cm
10–12 in

RED GENERAL STARFISH
Protoreaster lincki
F: Oreasteridae

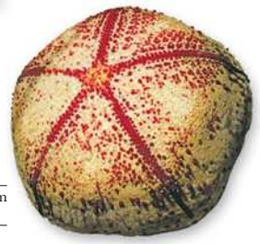
From the cushion star family, this Indian Ocean species grazes on algae as a juvenile, but preys on other invertebrates when adult.



20–27 cm
8–10½ in

GRANULATED STARFISH
Choriaster granulatus
F: Oreasteridae

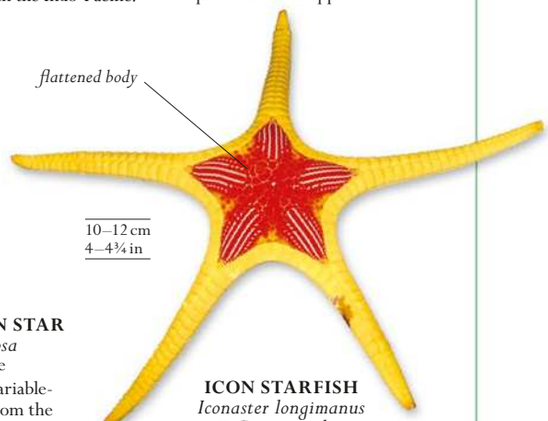
A giant Indo-Pacific echinoderm of rubble slopes and coral reefs, this cushion star grazes on algae and detritus in shallow waters.



20–25 cm
8–10 in

INDO-PACIFIC CUSHION STAR
Culcita novaeguineae
F: Oreasteridae

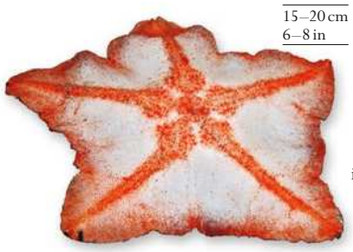
This coral-feeder of the Indo-Pacific belongs to a family of starfish that become shorter-armed as they get bigger, eventually maturing into dumpy cushion shapes.



10–12 cm
4–4¾ in

ICON STARFISH
Iconaster longimanus
F: Goniasteridae

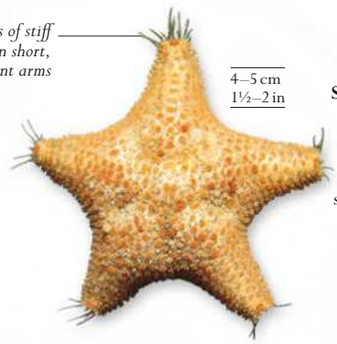
Many echinoderms develop from planktonic larvae, but this Indo-Pacific starfish lacks a larval stage. It produces large yolky eggs.



15–20 cm
6–8 in

GOOSEFOOT STARFISH
Anseropoda placenta
F: Asterinidae

A thin flat starfish with ill-defined arms, the goosefoot starfish of the E. Atlantic is a predator of bottom-dwelling crustaceans.



4–5 cm
1½–2 in

SMALL CUSHION STAR
Asterina gibbosa
F: Asterinidae

This short-armed variable-coloured starfish, from the same family as the goosefoot, scavenges dead material on the rocky coasts of the N.E. Atlantic.

CHORDATES

Only three to four per cent of known animal species are chordates, yet they include the largest, fastest, and most intelligent animals alive today. Most chordates have a skeleton made of bone or cartilage, but their defining feature is the rod-like notochord – the evolutionary forerunner of the spine.

Fossil records indicate that the earliest known true chordates were small, streamlined animals, just a few centimetres long. Living at least 500 million years ago, they had no hard parts, except for a stiff but flexible cartilaginous notochord. The notochord ran the length of their body, creating a framework for their muscles to pull against. Today's chordates all have this feature, and a small number keep it throughout life. However, in the vast majority of chordates – from fish and amphibians to reptiles, birds, and mammals – the notochord is present only in the early embryo. As the embryo develops, the notochord disappears, replaced by an internal skeleton made of cartilage or bone. These animals are known as vertebrates, from the column of vertebrae that makes up their spine.

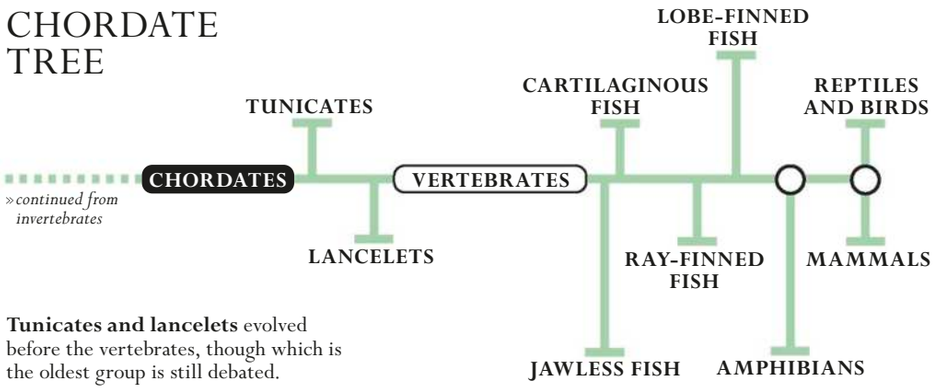
Unlike shells or body cases, bony skeletons work on an amazing spectrum of scales. The smallest vertebrate, a freshwater fish called *Paedocypris progenetica*, is less than 1 cm (⅜ in) long and weighs several billion times less than a blue whale, which is the largest chordate, and the biggest animal that has ever lived.

LIFESTYLES

It is perhaps surprising that one of the simplest chordate groups, the sea squirts (tunicates), do not have a skeleton or backbone, and spend their adult lives fastened in one place. However, in their planktonic larval stage they do have a notochord, indicating their shared ancestry with vertebrate chordates such as us. In contrast to these simple chordates, vertebrate chordates are often fast-moving animals, with rapid reactions, a well-developed nervous system, and a sizeable brain. Birds, mammals, and a few fish use energy from food to keep their body at a constant optimum temperature.

Chordates vary in the way they reproduce and raise their young. All mammals bear live young, apart from the duck-billed platypus and echidnas. Almost all other chordates lay eggs, though there are examples of live-bearing species in all vertebrate groups except birds. The number of offspring produced is related to the amount of parental care. Some fish produce millions of eggs, and play no part in raising their young, whereas mammals and birds have much smaller families.

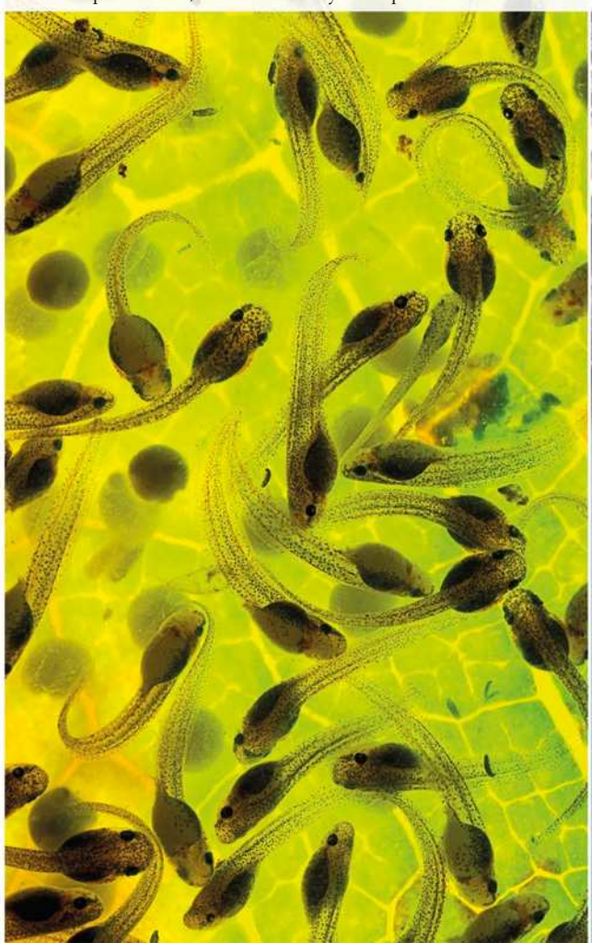
CHORDATE TREE



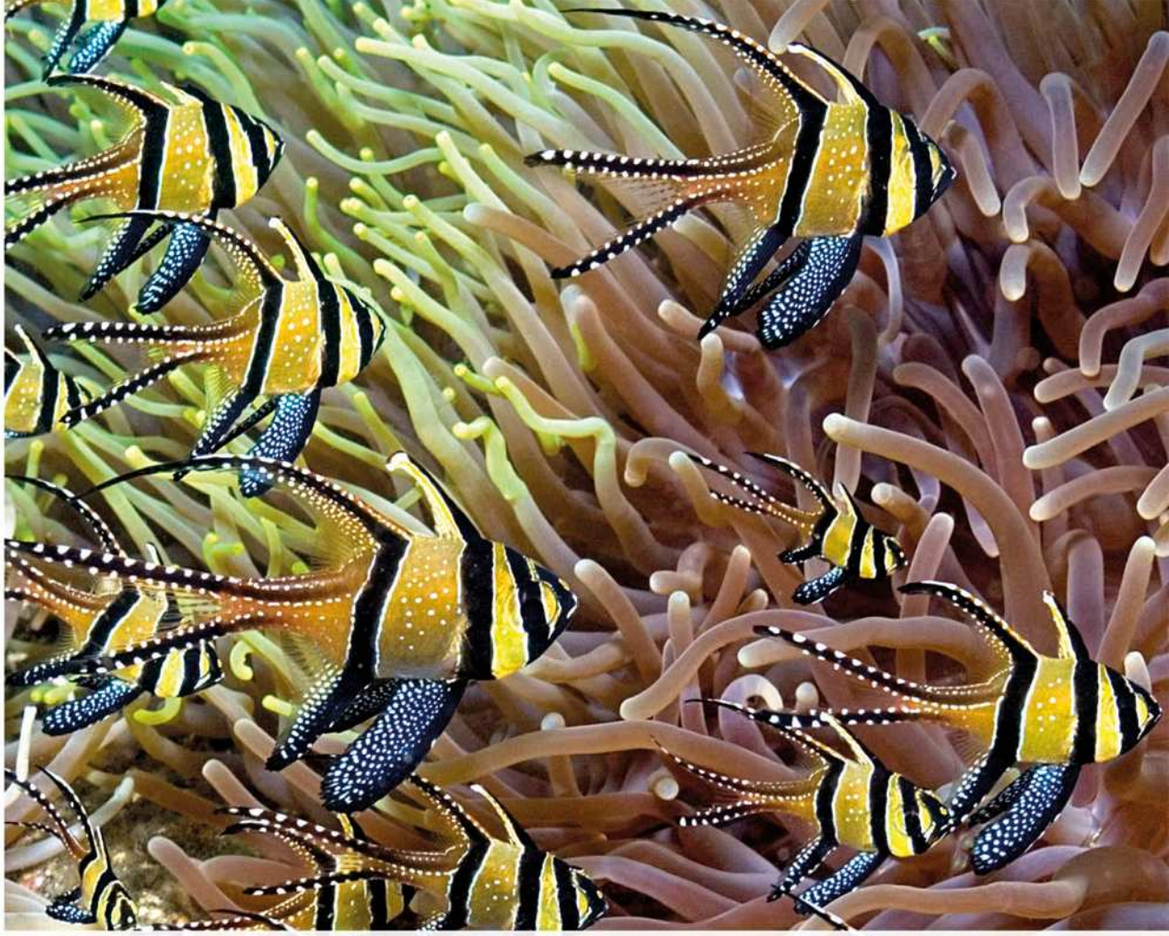
Tunicates and lancelets evolved before the vertebrates, though which is the oldest group is still debated.

TUNICATES
The subphylum Tunicata contains just over 3,000 species. Larval tunicates have a notochord, and resemble tadpoles. The adults are filter feeders, the most common type being sea squirts.

AMPHIBIANS
Numbering over 8,200 species, amphibians include frogs and toads, salamanders, newts, and caecilians. Most start their lives as aquatic larvae, but as adults they take up life on land.



LANCELETS
Small marine chordates with slender bodies and a notochord throughout life, lancelets live half buried in the seabed. There are 20 species in the subphylum Cephalochordata.



FISH
Fish are the most diverse and numerous of all the vertebrate chordates. They are classified into a number of different classes, within the subphylum Vertebrata. These classes of fish are often grouped together as a superclass, Pisces, and their variety reflects their evolutionary past. Almost 34,000 living species are known.

REPTILES
With over 11,000 species, reptiles inhabit every continent on Earth, with the exception of Antarctica. Unlike birds and mammals, they are cold-blooded, and covered in scales.

BIRDS
Birds are the only living animals that have feathers. There are around 10,000 species of birds, though recent studies suggest there may be up to 18,000. All lay eggs, and many show highly developed parental care.

MAMMALS
Readily identified by their fur or hair (even whales have some), mammals are the only chordates that raise their young on milk. There are over 6,300 known mammal species.

FISH

Fish are the most diverse chordates and can be found in all types of watery habitat – from tiny, freshwater pools to the deep ocean. Almost without exception, they breathe using feathery gills to absorb oxygen from the water, and almost all swim using fins.

PHYLUM	CHORDATA
CLASSES	PETROMYZONTI MYXINI ELASMOBRANCHII HOLOCEPHALI ACTINOPTERYGII COELACANTHI DIPNEUSTI
ORDERS	66–81
FAMILIES	560–588
SPECIES	About 33,900

Overlapping scales cover the body of a bicolour parrotfish, forming a flexible layer that protects against injury.

Predatory sharks lunge into a huge shoal of sardines, which swim ever closer together for protection.

The huge mouth of a male gold-specs jawfish provides an unlikely nest for its eggs. He will not feed during incubation.

Fish are not a natural, single group but are in fact seven classes of vertebrate chordates, of which the familiar ray-finned (bony) fish are by far the most populous. The majority of fish are cold-blooded and so their body temperature matches that of the surrounding water. A few top predators, such as white sharks, can maintain a flow of warm blood to the brain, eyes, and main muscles, which allows them to hunt actively even in very cold water. Most fish are protected by scales or bony plates embedded in the skin. In fast swimmers these are lightweight, and provide streamlining as well as protection from abrasion and disease. Although a few fish slither or shuffle over the seabed, most swim using fins. With the notable exception of rays, the tail fin usually provides the main propulsive force. Paired pectoral and pelvic fins (on the sides and underside respectively) provide stability and manoeuvrability, helped by up to three dorsal fins on the fish's upper side and one or two anal fins. Fish avoid collisions – especially in large shoals – by using special sensory organs that detect the vibrations made as they or other animals move through the water. Most fish have a row of these organs running along both sides of the body, called the lateral line. While they also use the senses of hearing, touch, sight, taste, and smell found in other chordates, only fish have a lateral line system.

REPRODUCTIVE STRATEGIES

The seven classes of fish have very different ways of reproducing. Most ray-finned fish have external fertilization and shed masses of eggs and sperm directly into the water to compensate for the huge numbers that are eaten before they can develop into juvenile fish; a few instead guard their eggs until hatching. In contrast, cartilaginous fish (sharks, rays, and chimaeras) all have internal fertilization and produce eggs or young at an advanced developmental stage. This requires a high input of energy – only a few young are produced at one time, but these have a good chance of survival. The eggs of lampreys (jawless fish) hatch into larvae that live and feed for many months before undergoing metamorphosis into the adult form.

BRIGHT SPECTACLE >
The fabulous colours of the Banggai cardinalfish, seen here sheltering among giant anemones, attract aquarium owners.

FISH GROUPS

The seven classes show fundamental differences, especially in skeleton and gills, but also many similarities in body form required to function in an aquatic environment.

JAWLESS FISH

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CARTILAGINOUS FISH

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RAY-FINNED FISH

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LOBE-FINNED FISH

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JAWLESS FISH

Unlike all other vertebrates, jawless fish have no biting jaws, although they do have teeth. Once abundant and diverse, few living representatives remain.

There are two living groups of jawless fish – lampreys and hagfish – and the relationship between them is still debated. Instead of jaws, lampreys have a round, sucker mouth encircled by rasping teeth, while hagfish have a slit-like mouth with teeth inside on the tongue. Circular gill openings run along the sides, seven in lampreys and a variable number (1–16) in hagfish. For body support and muscle attachment, both groups have a simple, rod-like structure called a notochord. In addition, lampreys may have a few cartilage supports around the notochord.

DIFFERING LIFECYCLES

While hagfish live permanently in the deep ocean, lampreys inhabit temperate coastal waters and fresh waters worldwide. All lampreys breed in fresh water. Coastal species are anadromous – that is, like salmon, they swim up rivers into fresh water to spawn, after which they die. The eggs hatch into worm-like, burrowing larvae, known as ammocoetes. These live in mud and feed on detritus. After about three years the larvae of the anadromous species change into adults and swim out to sea where they feed for several years. The freshwater species live and breed in rivers and lakes. Hagfish lay eggs on the seabed.

PARASITES AND SCAVENGERS

Lampreys are notorious for feeding parasitically on larger fish when they are adult. Clinging on with its sucker mouth, a lamprey grinds its way through the skin of its victim eating either, or both, flesh and blood. They can be a nuisance to fishermen as they damage and kill fish in nets and fish farms. However, many lampreys, especially freshwater species, just eat small invertebrates. The sucker mouth is also useful when the fish are swimming upstream against the current – they use it to cling onto rocks so they can have a rest and to move pebbles when excavating a nest site in the river bed.

Hagfish live in mud burrows in the seabed, emerging at night to feed on both live and dead invertebrates. If the opportunity arises, they will feed on rotting whale or fish carcasses, from which they rasp off bits of flesh. If attacked, hagfish produce copious, gill-clogging slime to deter the predator.

PHYLUM	CHORDATA
CLASSES	PETROMYZONTI
	MYXINI
ORDERS	2
FAMILIES	4
SPECIES	128

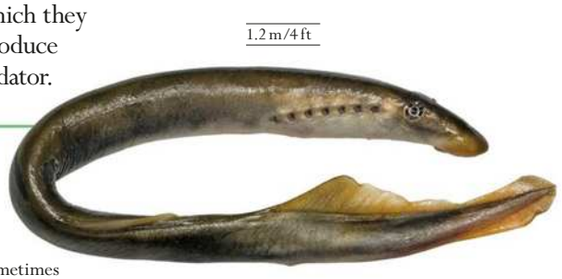
DEBATE

ARE LAMPREYS AND HAGFISH RELATED?

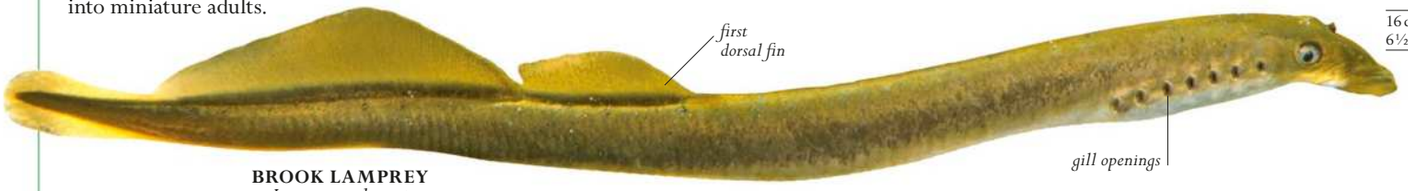
Traditionally lampreys and hagfish were classified together as Cyclostomata, separate from jawed vertebrates. Detailed morphological comparisons and early molecular work allied lampreys with jawed vertebrates, leaving hagfish as a non-vertebrate chordate. Since about 2010, advanced genetic techniques (of micro-RNAs) have provided strong evidence for grouping them together once again.

LAMPREYS AND HAGFISH

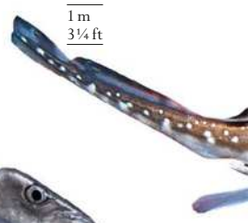
The orders Petromyzontiformes and Myxiniformes are the only two groups of living jawless fish – often called agnathans. They share an eel-like shape, lack of jaws, and possession of a notochord, but also have numerous anatomical differences. Lampreys have a long larval stage spent in fresh water, while hagfish lay eggs on the seabed that hatch into miniature adults.



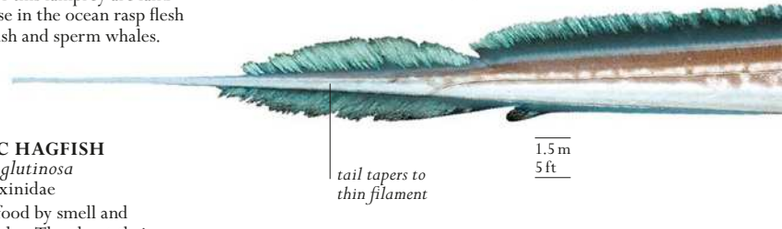
SEA LAMPREY
Petromyzon marinus
F: Petromyzontidae
Salmon in the North Atlantic sometimes fall prey to this parasitic fish which latches onto its victim and scrapes out its flesh.



BROOK LAMPREY
Lampetra planeri
F: Petromyzontidae
Larvae and adults of this common northern European lamprey live in streams and rivers. Once metamorphosis has taken place, the adults stop feeding and devote all their energy to spawning, after which they die.



PACIFIC LAMPREY
Entosphenus tridentatus
F: Petromyzontidae
Some populations of this lamprey are land-locked in lakes. Those in the ocean rasp flesh and blood from fish and sperm whales.



ATLANTIC HAGFISH
Myxine glutinosa
F: Myxinidae
Hagfish detect food by smell and their sensory tentacles. They knot their body to give leverage when feeding and to slide off defensive slime. This species lives in the N. Atlantic and Mediterranean.

CARTILAGINOUS FISH

These fish have a skeleton of pliable cartilage rather than the hard bone found in most other vertebrate groups. Most are predators with acute senses.

Sharks, rays, and chimaeras are all cartilaginous fish although chimaeras have distinct anatomical differences from the other two groups. In chimaeras, the upper jaw is fused to the braincase and so cannot be moved independently. They also have teeth that grow continuously. In contrast, sharks regularly lose their hard enamel-covered teeth but replace them from extra rows lying flat behind the active teeth – a characteristic that helps make sharks some of the most formidable predators on Earth. The skin of all three groups – sharks, rays, and chimaeras – is protected by tooth-like scales called dermal denticles.

SEARCHING FOR PREY

The ocean is home to most cartilaginous fish and while many live on the seabed, the larger predatory shark species and plankton feeders roam in open water. The bullshark and over 100 other species can enter estuaries and swim up rivers and a few live entirely in rivers. Most open-water cartilaginous fish are continually on the move because, unlike bony fish, they do not have a gas-filled swim bladder to maintain neutral buoyancy and therefore may sink if they stop swimming. The whale shark and other surface-feeding species have a large oily liver to prevent this. Predatory sharks are well known for their amazing ability to smell blood and home in on wounded fish and mammals. Cartilaginous fish also have the ability to detect the weak electrical fields that surround living creatures and while not unique to them, this sense is developed to an extraordinary extent in this group.

REPRODUCTION

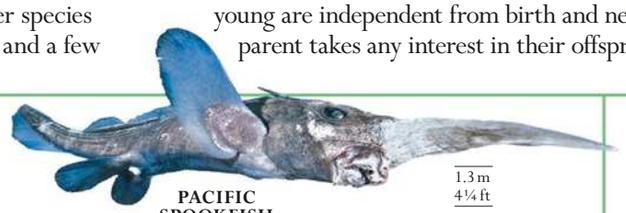
All cartilaginous fish mate and have internal fertilization. Chimaeras and many smaller sharks and rays lay eggs, each protected by a tough egg capsule and commonly known as a "mermaid's purse". However, around sixty per cent of cartilaginous fish give birth to well-developed live young that are nourished in the uterus by egg yolk or by a placental connection to the mother. Unlike mammals, the young are independent from birth and neither parent takes any interest in their offspring.

PHYLUM	CHORDATA
CLASSES	ELASMOBRANCHII
	HOLOCEPHALI
ORDERS	14–17
FAMILIES	57
SPECIES	1,338

A white shark, *Carcharodon carcharias*, shows the razor-sharp, replaceable rows of teeth that make it such a fearsome predator.

CHIMAERAS

Also known as rabbitfish because of their fused plate-like teeth, the Holocephali are a small class of cartilaginous fish with one order, Chimaeriformes, and about 56 species. A strong, venomous spine in front of the first of two dorsal fins provides protection in their deepwater habitat.



1.3 m
4¼ ft

PACIFIC SPOOKFISH
Rhinochimaera pacifica
F: Rhinochimaeridae

The long, conical snout of this chimaera is covered in sensory pores that detect the electrical fields of its prey.

1.3 m
4¼ ft

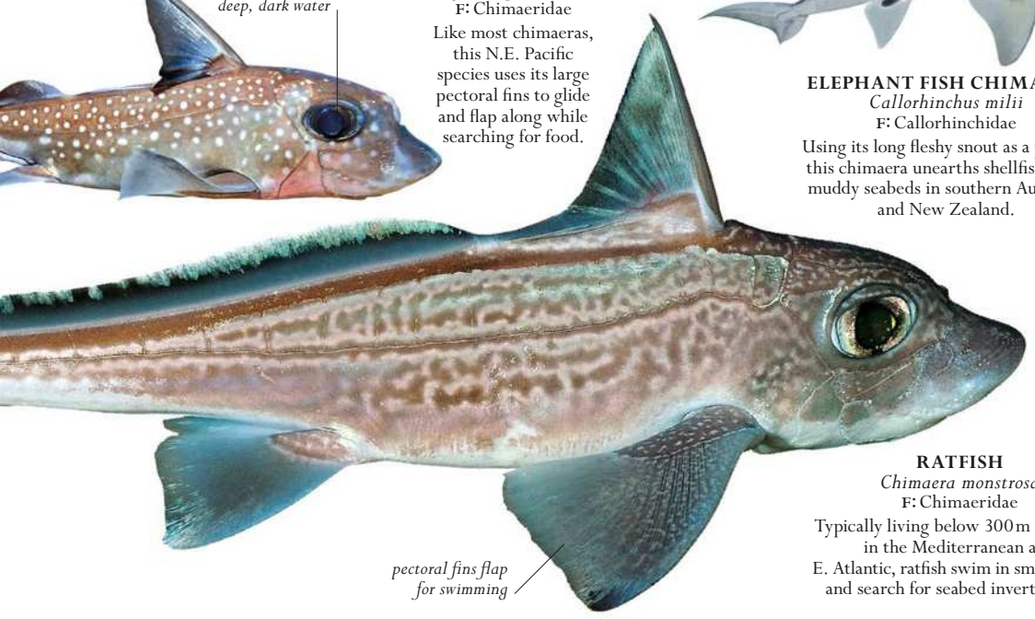
ELEPHANT FISH CHIMAERA
Callorhinchus milii
F: Callorhinchidae

Using its long fleshy snout as a plough, this chimaera unearths shellfish from muddy seabeds in southern Australia and New Zealand.

large eye provides better vision in deep, dark water

SPOTTED RATFISH
Hydrolagus colliei
F: Chimaeridae

Like most chimaeras, this N.E. Pacific species uses its large pectoral fins to glide and flap along while searching for food.



pectoral fins flap for swimming

RATFISH
Chimaera monstrosa
F: Chimaeridae

Typically living below 300 m (1,000 ft) in the Mediterranean and E. Atlantic, ratfish swim in small groups and search for seabed invertebrates.

SIX- AND SEVEN-GILL SHARKS

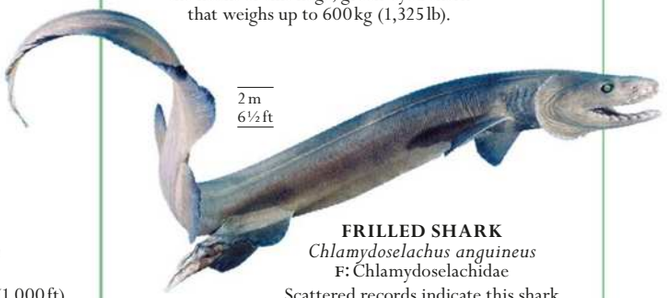
Most sharks have five pairs of gill slits, but those in the order Hexanchiformes have either six or seven pairs. All six known species live in deep water. Two of them, called frilled sharks, have a long, soft, eel-like body and have recently been placed in their own order, Chlamydoselachiformes.

5.5 m
18 ft

BLUNTNOSE SIXGILL SHARK
Hexanchus griseus
F: Hexanchidae

Rocky seamounts around the world are the haunt of this huge, green-eyed shark that weighs up to 600 kg (1,325 lb).

2 m
6½ ft



FRILLED SHARK
Chlamydoselachus anguineus
F: Chlamydoselachidae

Scattered records indicate this shark has a worldwide distribution. It has brilliant white teeth that may attract its prey of fish and squid.

DOGFISH SHARKS AND RELATIVES

A large and varied order, the Squaliformes contains at least 143 species and includes gulper, lantern, sleeper, and kitefin sharks. These all have two dorsal (back) fins and no anal fin. All species so far studied bear live young.

PIKED DOGFISH
Squalus acanthias
F: Squalidae

Found worldwide in temperate waters this once hugely abundant shark is endangered by overfishing. Living up to an age of 100, it grows and breeds very slowly.

COOKIECUTTER SHARK
Isistius brasiliensis
F: Dalatiidae

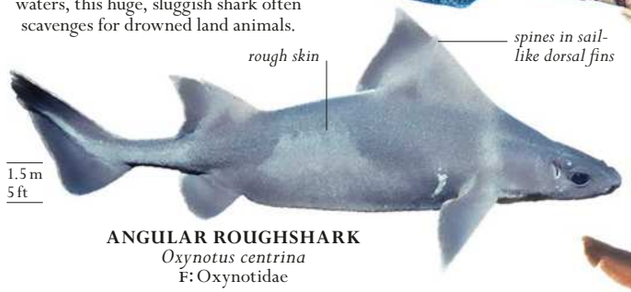
This widespread, tropical shark is an ectoparasite of dolphins and large fish. Sucking on with thick lips, it twists round and bites out a round plug of flesh.

VELVET BELLY LANTERN SHARK
Etmopterus spinax
F: Etmopteridae

This lantern shark lives in the deep E. Atlantic. It has tiny light organs on its belly, which help in finding a mate.

GREENLAND SHARK
Somniosus microcephalus
F: Somniosidae

One of only a few sharks that live in Arctic waters, this huge, sluggish shark often scavenges for drowned land animals.

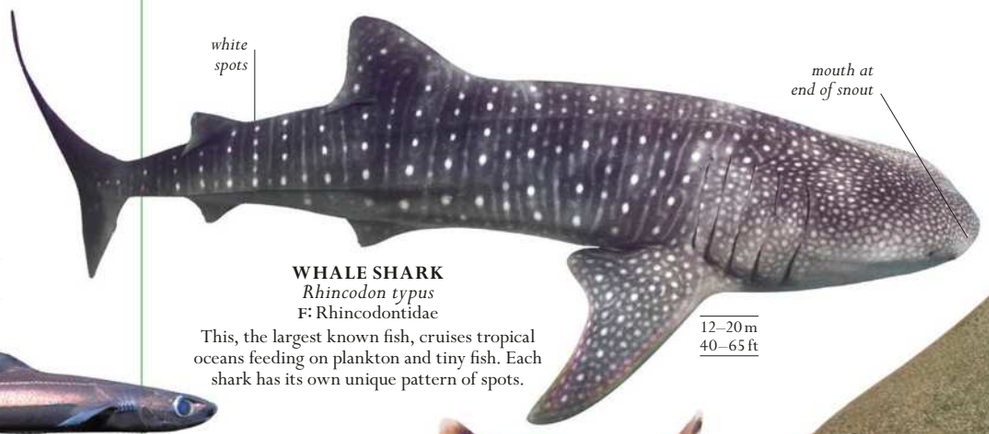


ANGULAR ROUGHSHARK
Oxynotus centrina
F: Oxynotidae

Recently placed in its own order Echinorhiniformes, this deep-water shark has two sail-like dorsal fins and rough skin. It lives in the E. Atlantic.

CARPET SHARKS

The 46 or so sharks of the Orectolobiformes have two dorsal fins, one anal fin, and sensory barbels hanging down from the nostrils. With the exception of the whale shark, they live quietly on the seabed, feeding on fish and invertebrates.

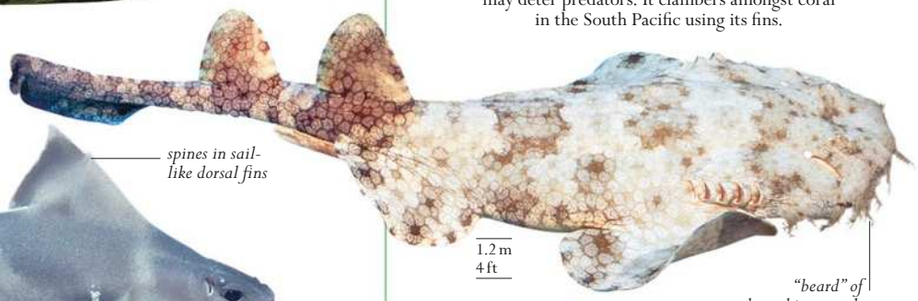


WHALE SHARK
Rhincodon typus
F: Rhincodontidae

This, the largest known fish, cruises tropical oceans feeding on plankton and tiny fish. Each shark has its own unique pattern of spots.

EPAULETTE CATSHARK
Hemiscyllium ocellatum
F: Hemiscylliidae

The bold eyespot mark of this long-tailed shark may deter predators. It clambers amongst coral in the South Pacific using its fins.



TASSELLED WOBBEGONG
Eucrossorhinus dasypogon
F: Orectolobidae

With its fringe of skin tassels, flattened body, and camouflage pattern, this S.W. Pacific coral reef resident is hard to spot.

NURSE SHARK
Ginglymostoma cirratum
F: Ginglymostomatidae

By day this shark lies hidden in rock crevices, emerging at night to hunt in the warm coastal waters of the Atlantic and the E. Pacific.

SAWSHARKS

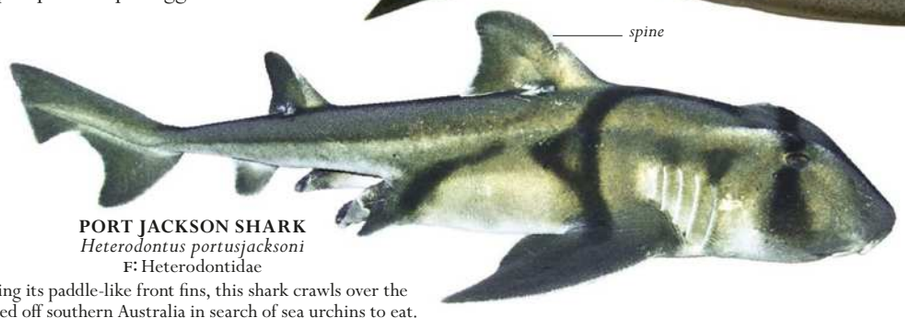
Sawsharks have a flat head with gills on the sides and a long snout (rostrum) with teeth on the underside and edges. Two long sensory barbels hang from the rostrum and help find buried food. Most of the nine species of Pristiophoriformes live in the tropics.

LONGNOSE SAWSHARK
Pristiophorus cirratus
F: Pristiophoridae

Sandy seabeds off southern Australia are home to this sawshark. It may use its rostrum to deter predators as well as kill prey.

BULLHEAD SHARKS

The Heterodontiformes are small bottom-living sharks with a blunt, sloping head, crushing teeth, and two dorsal (back) fins each preceded by a sharp spine. They lay unique spiral-shaped eggs.



PORT JACKSON SHARK
Heterodontus portusjacksoni
F: Heterodontidae

Using its paddle-like front fins, this shark crawls over the seabed off southern Australia in search of sea urchins to eat.

ANGELSHARKS

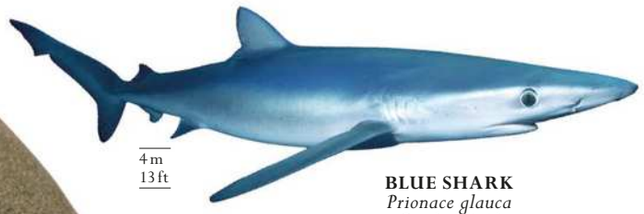
Flattened from top to bottom, angelsharks have gill slits on the sides of their large head. This distinguishes them from the similarly shaped rays, which have gills underneath. The order Squatiniformes contains just one family, which has 25 members. Angelsharks rear up from the seabed on their pectoral fins to ambush prey.

1.5 m
5 ft

SAND DEVIL
Squatina dumeril
F: Squatinidae
Sandy seabeds in the N.W. Atlantic are home to this well-camouflaged predator. It strikes at passing fish with lighting speed.

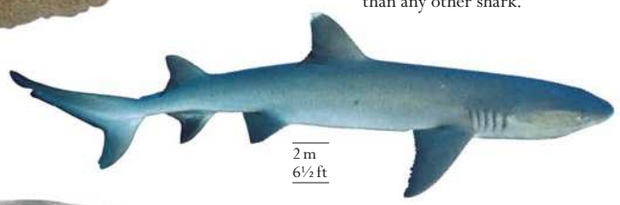
GROUND SHARKS

There are about 295 species of Carcharhiniformes, making this the largest and most diverse order of sharks. Most are large predators, although the small yet numerous cat sharks are also included in the order. All have two dorsal fins and one anal fin.



4 m
13 ft

BLUE SHARK
Prionace glauca
F: Carcharhinidae
Streamlined and elegant, this species travels vast distances between feeding and breeding grounds. More blue sharks are caught than any other shark.

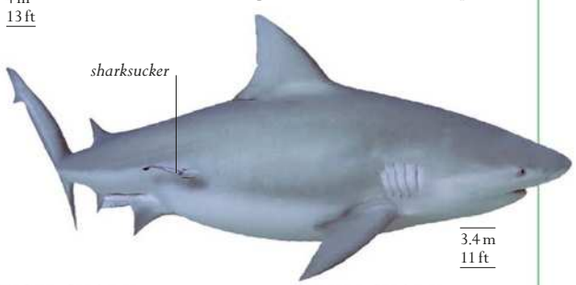


2 m
6½ ft

WHITETIP REEF SHARK
Triaenodon obesus
F: Carcharhinidae
This is perhaps the most common shark on the coral reefs of the Indian and Pacific oceans. It hunts fish at night, sometimes in frenzied packs.

4 m
13 ft

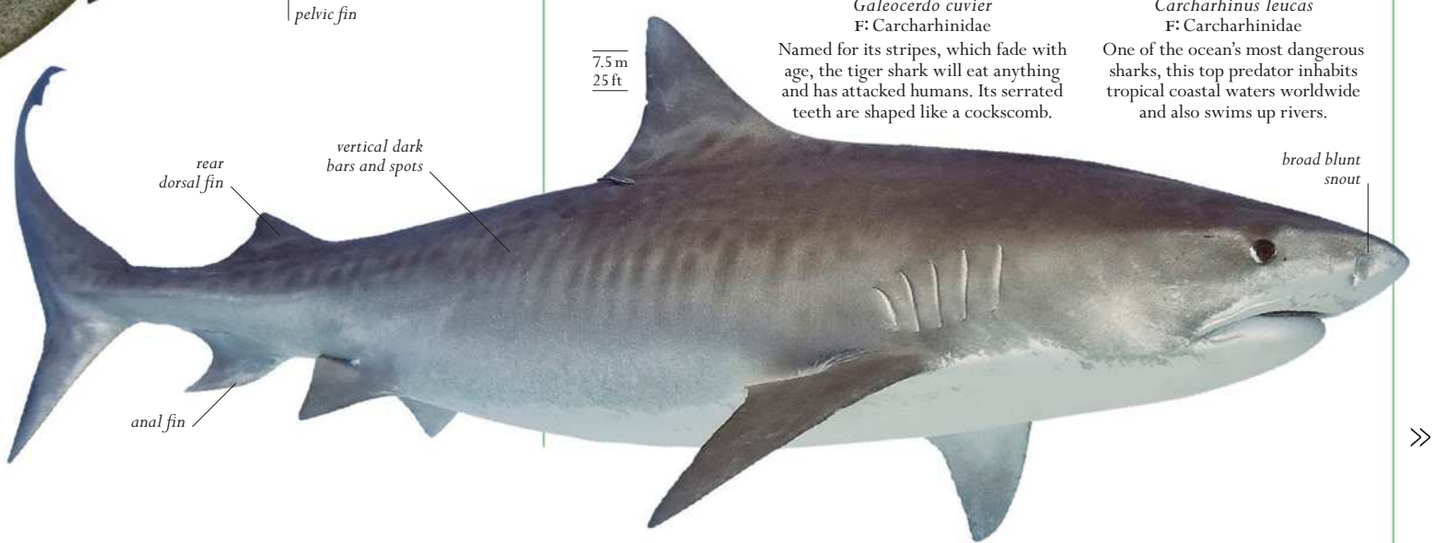
OCEANIC WHITETIP SHARK
Carcharhinus longimanus
F: Carcharhinidae
Heavily fished for its long, white-tipped dorsal and pectoral fins, this magnificent oceanic predator is now critically endangered.



3.4 m
11 ft

TIGER SHARK
Galeocerdo cuvier
F: Carcharhinidae
Named for its stripes, which fade with age, the tiger shark will eat anything and has attacked humans. Its serrated teeth are shaped like a cockscomb.

BULL SHARK
Carcharhinus leucas
F: Carcharhinidae
One of the ocean's most dangerous sharks, this top predator inhabits tropical coastal waters worldwide and also swims up rivers.



7.5 m
25 ft

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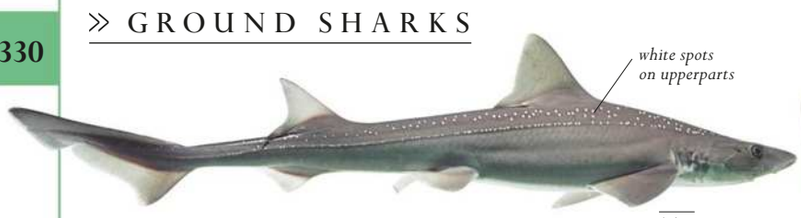
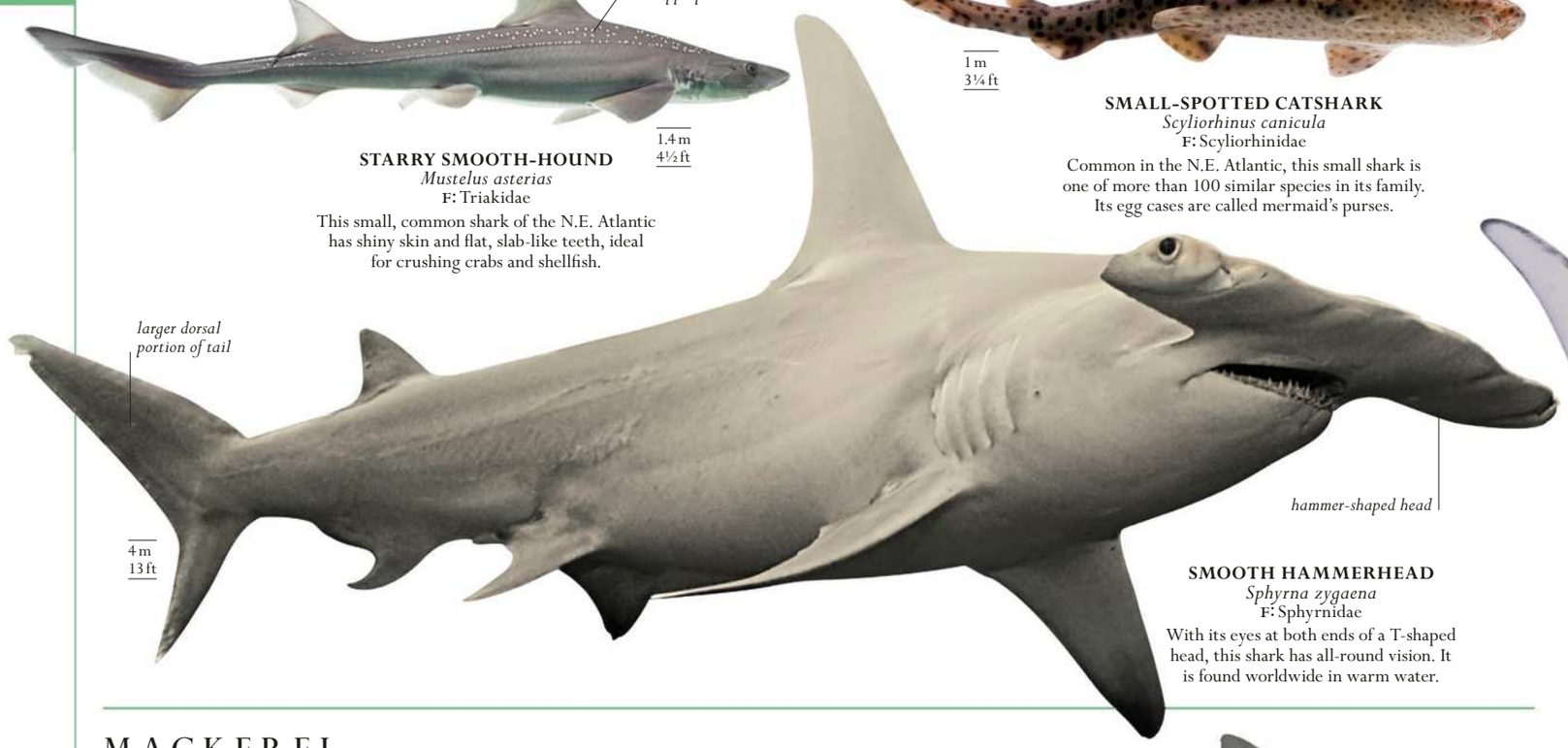


STARRY SMOOTH-HOUND
Mustelus asterias
F: Triakidae

This small, common shark of the N.E. Atlantic has shiny skin and flat, slab-like teeth, ideal for crushing crabs and shellfish.

SMALL-SPOTTED CATSHARK
Scyliorhinus canicula
F: Scyliorhinidae

Common in the N.E. Atlantic, this small shark is one of more than 100 similar species in its family. Its egg cases are called mermaid's purses.



SMOOTH HAMMERHEAD
Sphyrna zygaena
F: Sphyrnidae

With its eyes at both ends of a T-shaped head, this shark has all-round vision. It is found worldwide in warm water.

MACKEREL SHARKS

The 16 species of shark in this order are large with a cylindrical body and conical head. The Lamniformes are (mostly) fearsome hunters and many of them can maintain a high body temperature, allowing them to sustain speed in cold waters.

GOBLIN SHARK
Mitsukurina owstoni
F: Mitsukurinidae

This shark has jaws that shoot forward to grab its prey. Living in the dark depths of the Atlantic, Pacific, and W. Indian oceans, it detects prey using its flat, electro-sensitive, bill-like snout.

SAND TIGER SHARK
Carcharias taurus
F: Odontaspididae

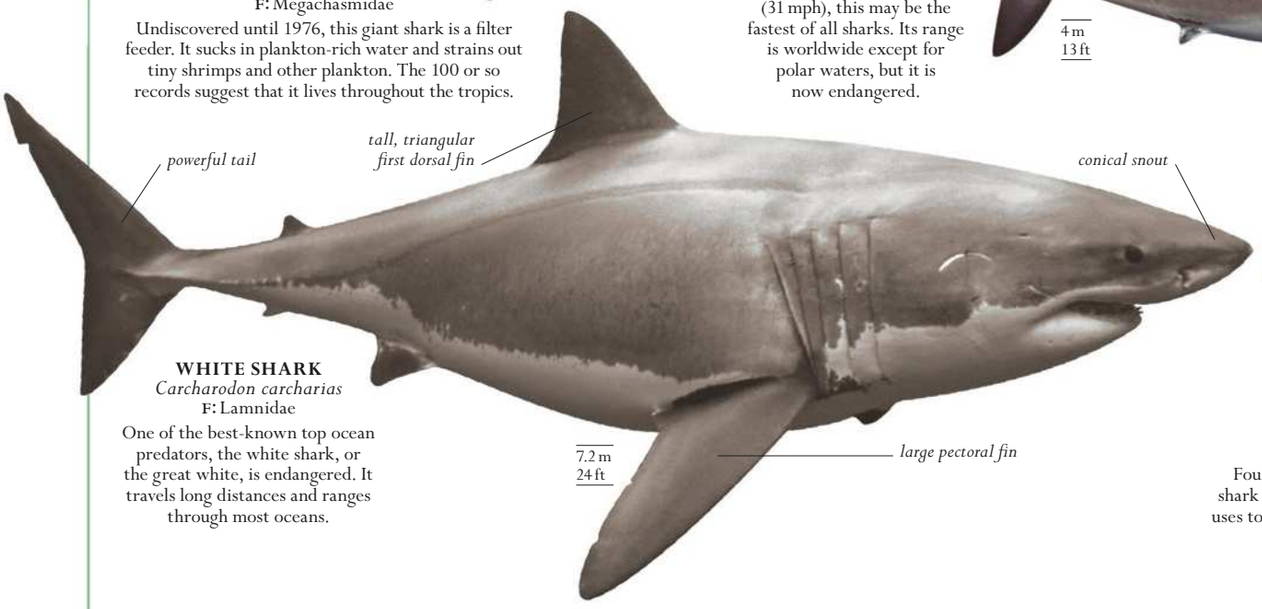
The menacing, dagger-like teeth of this large warm-water shark belie its docile nature. It is often kept in large public aquariums.

MEGAMOUTH SHARK
Megachasma pelagios
F: Megachasmidae

Undiscovered until 1976, this giant shark is a filter feeder. It sucks in plankton-rich water and strains out tiny shrimps and other plankton. The 100 or so records suggest that it lives throughout the tropics.

SHORTFIN MAKO
Isurus oxyrinchus
F: Lamnidae

Capable of reaching 50 kph (31 mph), this may be the fastest of all sharks. Its range is worldwide except for polar waters, but it is now endangered.



WHITE SHARK
Carcharodon carcharias
F: Lamnidae

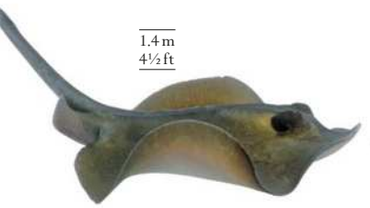
One of the best-known top ocean predators, the white shark, or the great white, is endangered. It travels long distances and ranges through most oceans.

THRESHER SHARK
Alopias vulpinus
F: Alopiidae

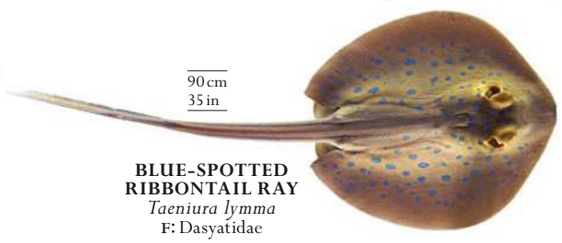
Found almost worldwide, the thresher shark has a tail as long as its body, which it uses to lash into fish shoals and stun its prey.

RAYS AND STINGRAYS

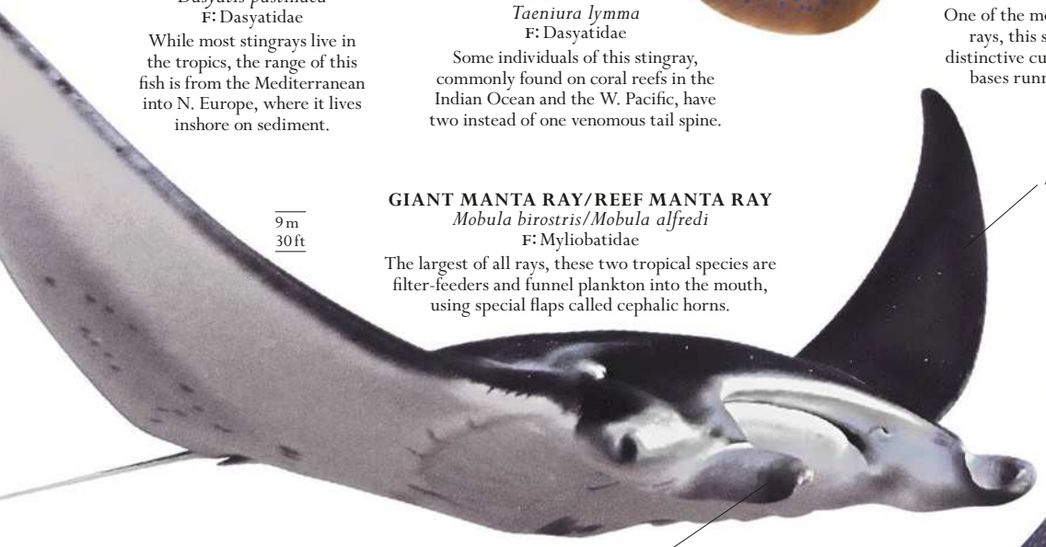
Most rays and skates (Rajiformes) and stingrays (Myliobatiformes) live on the seabed, athough they can swim by flapping their wing-like pectoral fins. Their flat, disc-shaped body is well-suited to this way of life. Stingrays have a long, thin tail armed with a venomous spine for protection. Some stingrays spend all or most of the time swimming and a few are found in fresh water.



COMMON STINGRAY
Dasyatis pastinaca
F: Dasyatidae
While most stingrays live in the tropics, the range of this fish is from the Mediterranean into N. Europe, where it lives inshore on sediment.

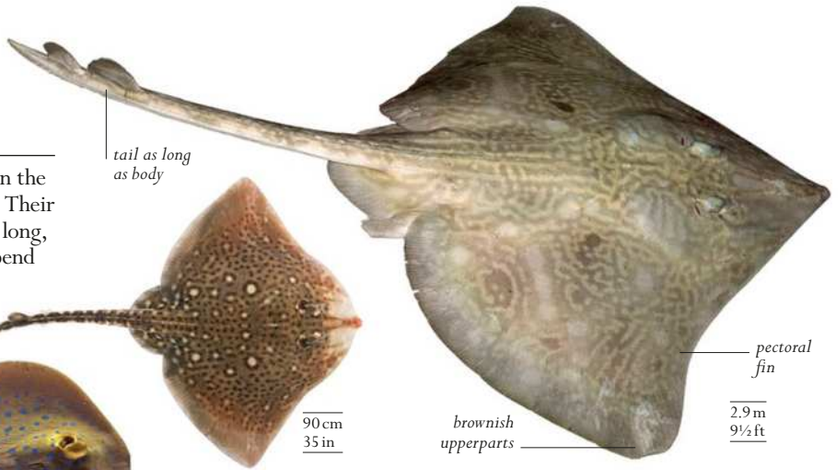


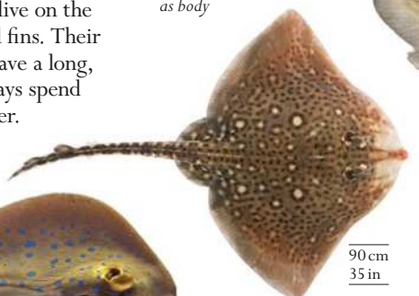
BLUE-SPOTTED RIBBONTAIL RAY
Taeniura lymma
F: Dasyatidae
Some individuals of this stingray, commonly found on coral reefs in the Indian Ocean and the W. Pacific, have two instead of one venomous tail spine.



GIANT MANTA RAY/REEF MANTA RAY
Mobula birostris/Mobula alfredi
F: Myliobatidae
The largest of all rays, these two tropical species are filter-feeders and funnel plankton into the mouth, using special flaps called cephalic horns.

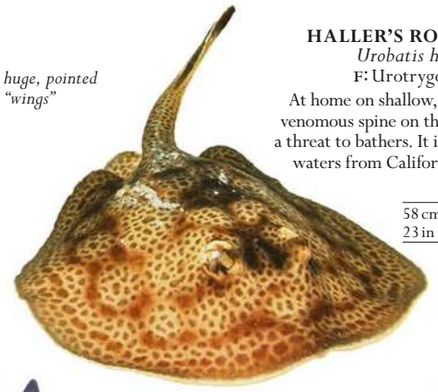
SPOTTED EAGLE RAY
Aetobatus narinari
F: Myliobatidae
This tropical stingray noses out molluscs from the sand. It swims well by beating its pectoral fins like a bird's wings.



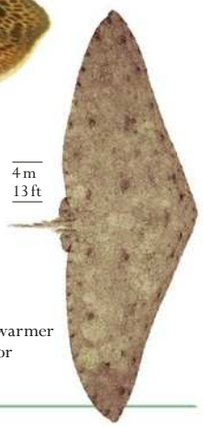


THORNBACK RAY
Raja clavata
F: Rajidae
One of the most common European rays, this species has a row of distinctive curved spines with wide bases running down its back.

BLUE SKATE
Dipturus flossada
F: Rajidae
One of two very similar, large European skates, this species is still sometimes known as *Dipturus batis*. It is distinguished by its long, pointed snout and blue underparts.



HALLER'S ROUND RAY
Urobatis halleri
F: Urotrygonidae
At home on shallow, sandy flats, the venomous spine on this stingray poses a threat to bathers. It is found in coastal waters from California to Panama.

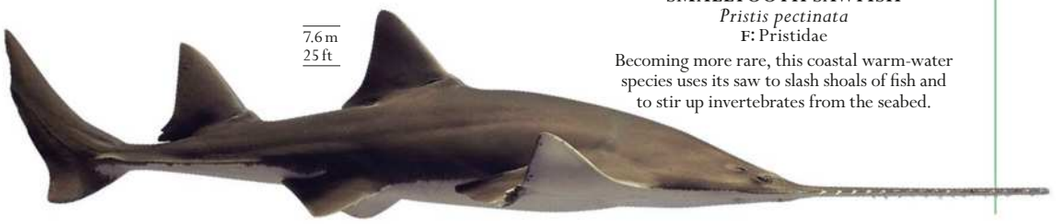


SPINY BUTTERFLY RAY
Gymnura altavela
F: Gymnuridae
This ray glides over the seabed in the warmer parts of the Atlantic, searching for invertebrates and fish.

SAWFISH AND GUITARFISH

Sawfish and guitarfish live and hunt on and near the seabed. They have a flattened body, but swim with their tail. Sawfish have a tough, blade-like snout, armed with regular-sized teeth on both edges. Superficially they resemble sawsharks, but, like rays, they have gills on their underside. Recent research places the seven species of sawfish with guitarfish in the order Rhinopristiformes.

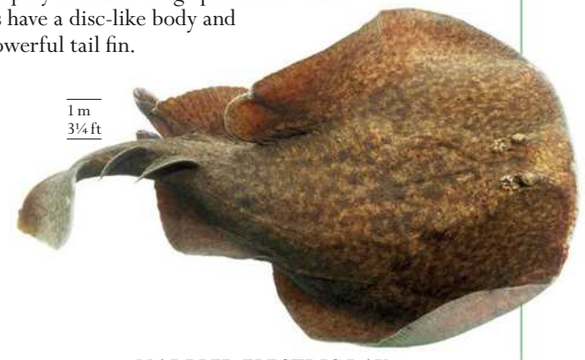
ATLANTIC GUITARFISH
Pseudobatos lentiginosus
F: Rhinobatidae
A shovel-shaped snout allows this fish to dig out molluscs and crabs from the sand. Found mainly in the Gulf of Mexico it is now increasingly rare.



SMALLTOOTH SAWFISH
Pristis pectinata
F: Pristidae
Becoming more rare, this coastal warm-water species uses its saw to slash shoals of fish and to stir up invertebrates from the seabed.

ELECTRIC RAYS

The pectoral fins of electric rays, order Torpediniformes, have special organs that produce enough electricity to stun prey and discourage predators. These rays have a disc-like body and a powerful tail fin.



MARBLED ELECTRIC RAY
Torpedo marmorata
F: Torpedinidae
When it pounces on a seabed fish, this electric ray can shock its prey with up to 200 volts. Electricity can be produced by even the newborn of this species.

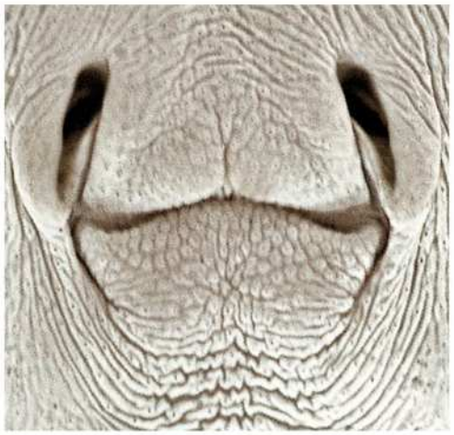
BLUE-SPOTTED RIBBONTAIL RAY

Taeniura lymma

Stingrays are notorious for the painful wounds they can inflict with their barbed tail, which can, in exceptional circumstances, be lethal. However, the tropical blue-spotted ribbontail ray, like other stingrays, uses its sting just to defend itself. Much of its time is spent resting motionless on sandy patches among coral, hidden under overhangs. Often only its blue-edged tail gives it away to divers – if disturbed, it will swim away, flapping its two wing-like pectoral fins. The best time to see one is on a rising tide when the stingrays swim inshore to feed on invertebrates in shallow water.

SIZE 70–90 cm (28–35 in), including tail
HABITAT Sandy patches in coral reefs
DISTRIBUTION Indian Ocean, W. Pacific
DIET Molluscs, crabs, shrimps, worms

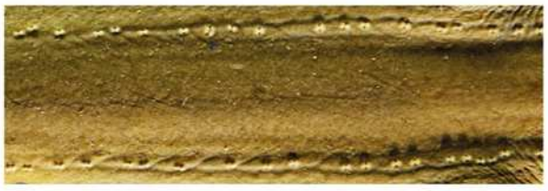
PELVIC FINS >
In this female the urogenital opening is visible between the pelvic fins on the underside. After mating, females produce up to seven live young following a few months' to a year's gestation.



< MOUTH
The mouth is on the underside of the stingray, allowing it to extract molluscs and crabs hidden beneath the surface of the sand. Two plates of small teeth within the mouth are used to crush the shells of its prey.

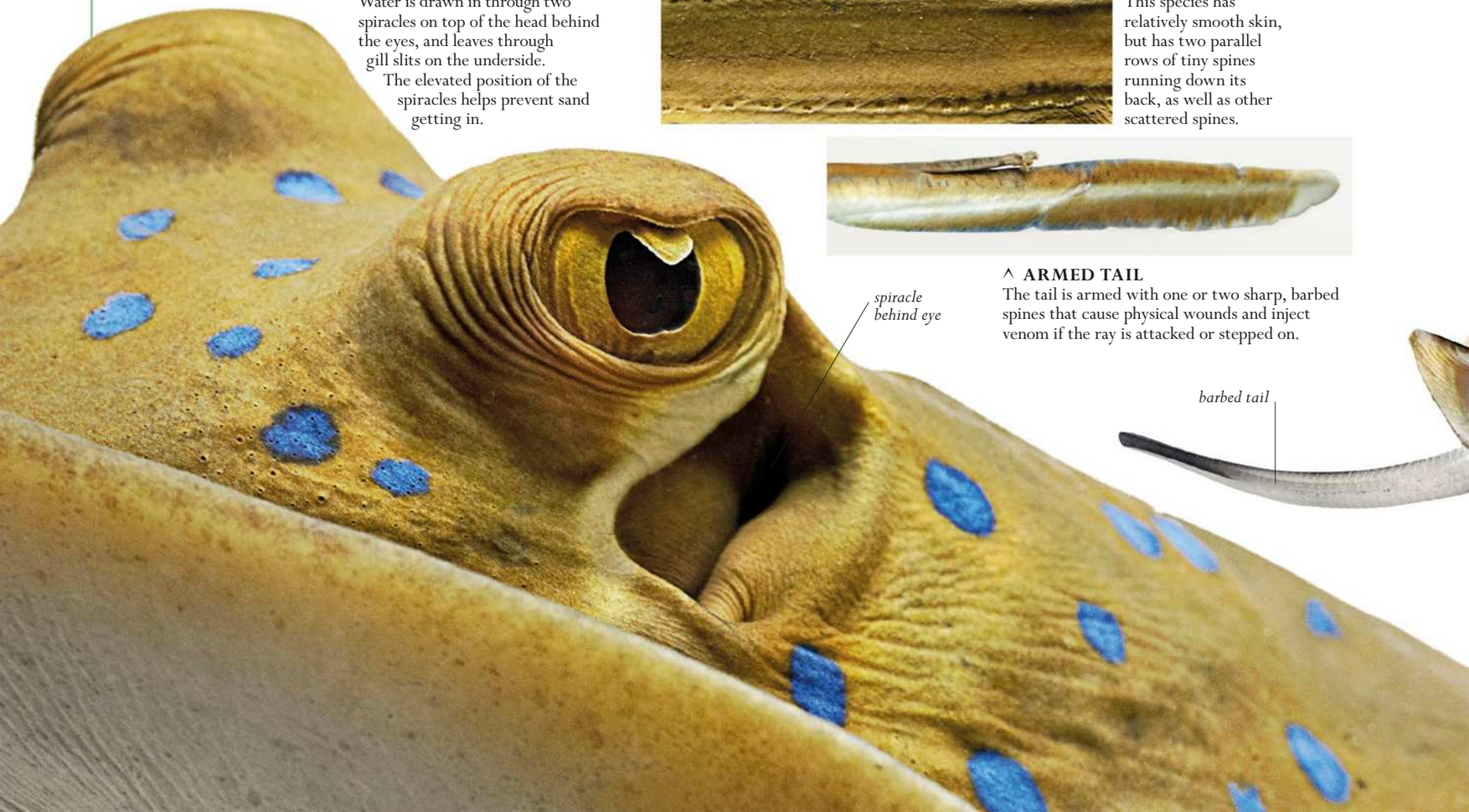
< GILL SLITS
After passing over the gills, water leaves the body through five pairs of gill slits on the underside.

∨ TOP HOLE
Water is drawn in through two spiracles on top of the head behind the eyes, and leaves through gill slits on the underside. The elevated position of the spiracles helps prevent sand getting in.

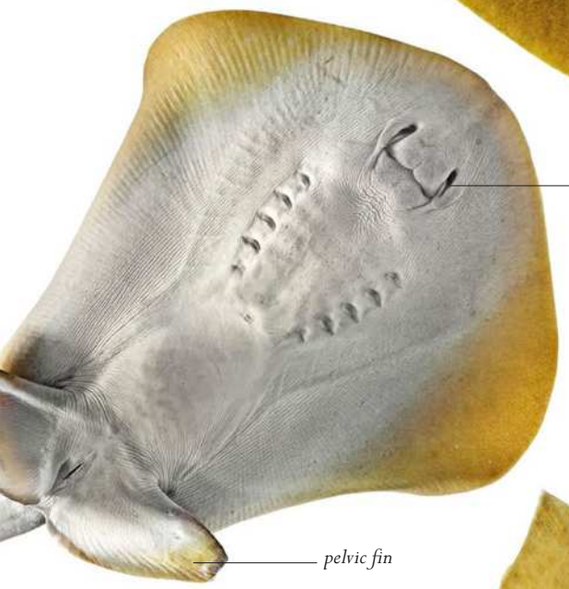


< BACK SPINES
This species has relatively smooth skin, but has two parallel rows of tiny spines running down its back, as well as other scattered spines.

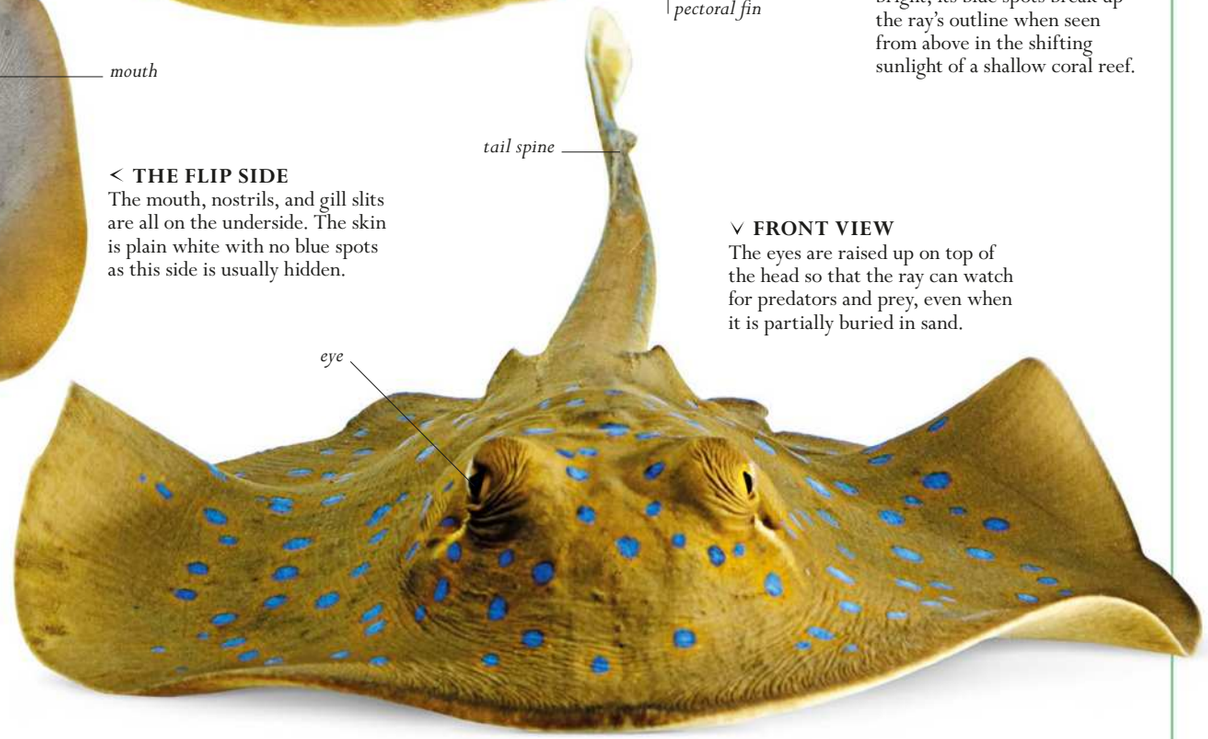
^ ARMED TAIL
The tail is armed with one or two sharp, barbed spines that cause physical wounds and inject venom if the ray is attacked or stepped on.



^ HIDDEN SPOTS
Unlike most of its relatives, the blue-spotted ribbontail ray rarely buries itself in sand, relying instead on its camouflage colours. Although bright, its blue spots break up the ray's outline when seen from above in the shifting sunlight of a shallow coral reef.



< THE FLIP SIDE
The mouth, nostrils, and gill slits are all on the underside. The skin is plain white with no blue spots as this side is usually hidden.



v FRONT VIEW
The eyes are raised up on top of the head so that the ray can watch for predators and prey, even when it is partially buried in sand.

RAY-FINNED FISH

These fish are bony, with a hard, calcified skeleton. Their fins are supported by a fan of jointed rods called rays, made of bone or cartilage.

Ray-finned fish are able to swim with far greater precision than cartilaginous fish. Using their highly mobile and versatile fins, they can execute manoeuvres such as hovering, braking, and even swimming backwards. The fins themselves can be delicate and flexible or strong and spiny and they often have important secondary uses, such as in defence, display, and camouflage.

With the exception of many bottom-living and deep-sea species, most ray-finned fish have a buoyancy aid in the form of a gas-filled swim bladder. This allows them to adjust their buoyancy at different depths by adding or removing gas to and from the bladder via the bloodstream.

MYRIAD ADAPTATIONS

The great majority of fish are ray-finned and the group is hugely diverse – ranging from tiny gobies to the gigantic ocean sunfish. Species have evolved to inhabit every conceivable aquatic niche from tropical coral reefs to the waters beneath the ice-shelves of Antarctica, from the depths of the ocean to shallow desert pools. Herbivores, carnivores, and scavengers are all represented in the group and its members exhibit many ingenious hunting and defence strategies, as well as co-operation between species.

SAFETY IN NUMBERS

Most ray-finned fish shed eggs and sperm into the water and fertilization is external. In some cases, fewer eggs are laid and parental care is provided. For example, jawfish and some cichlids protect their eggs and young in their mouth while sticklebacks and many wrasses build nests of weed and debris. Some species protect their eggs with such vigour that even scuba divers are warned off.

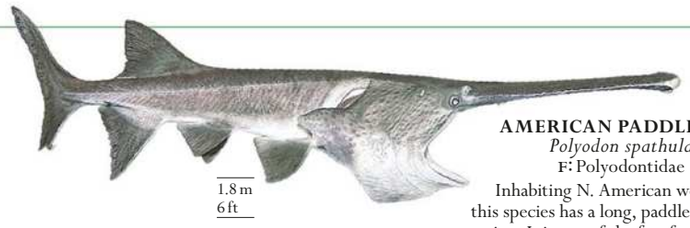
Most species, however, lay eggs in vast numbers. The millions of floating eggs and fish larvae are an important food source for other aquatic creatures, but those that survive drift and disperse the species. Populations of fish reproducing in this way are less vulnerable to over-fishing as numbers can recover when fishing stops, but stocks – even of such prolific breeders as Atlantic cod – will eventually succumb if intense levels of fishing are continued.

PHYLUM	CHORDATA
CLASS	ACTINOPTERYGII
ORDERS	47–59
FAMILIES	495–523
SPECIES	About 32,400

A pair of bluecheek butterflyfish (*Chaetodon semilarvatus*) swim in unison as they patrol their patch of coral reef.

STURGEONS AND RELATIVES

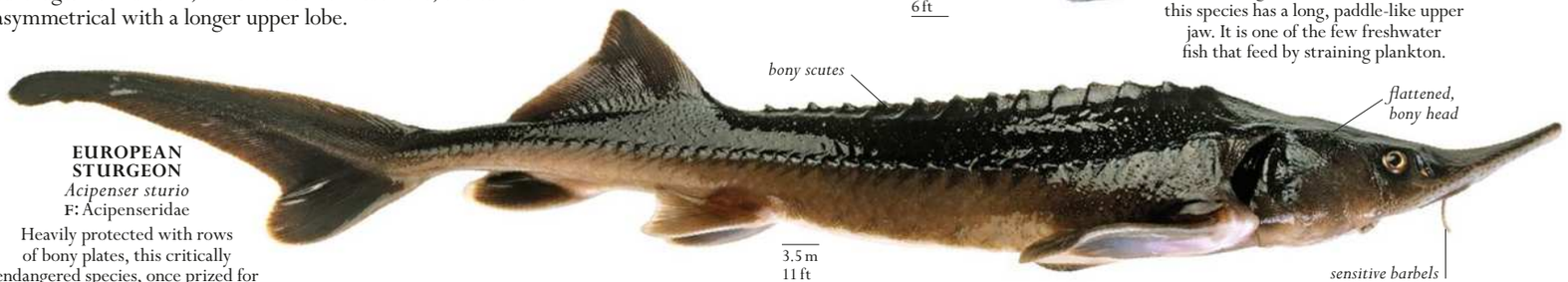
Among the 28 members of the order Acipenseriformes, only the sturgeon family includes marine species. The skull and some fin supports are made of hard bone, but most of the remaining skeleton is made of pliable cartilage. As in sharks, which these fish resemble, the tail is asymmetrical with a longer upper lobe.



1.8 m
6 ft

AMERICAN PADDLEFISH
Polyodon spathula
F: Polyodontidae

Inhabiting N. American wetlands, this species has a long, paddle-like upper jaw. It is one of the few freshwater fish that feed by straining plankton.



3.5 m
11 ft

EUROPEAN STURGEON
Acipenser sturio
F: Acipenseridae

Heavily protected with rows of bony plates, this critically endangered species, once prized for its caviar, inhabits coastal waters, but swims into rivers to breed.

GARS

Fish in the order Lepisosteiformes are primitive, freshwater predators from North America, with a long, cylindrical body protected by heavy, close-fitting scales. Their long jaws have needle-like teeth.

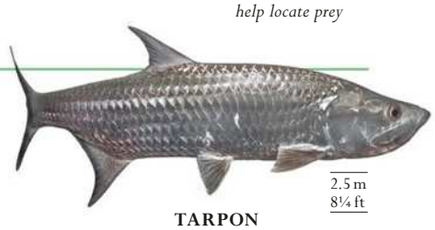
1.8 m
6 ft

LONGNOSE GAR
Lepisosteus osseus
F: Lepisosteidae

A skilled predator, this long, thin fish hangs motionless in the water, hidden by vegetation, before thrusting forwards to capture its prey.

TARPONS AND TENPOUNDERS

The order Elopiformes is small and its members are silvery with only one dorsal fin and a forked tail. They resemble giant herring. They have special throat bones (gular plates). Though these are marine fish, some species also swim up estuaries and rivers.



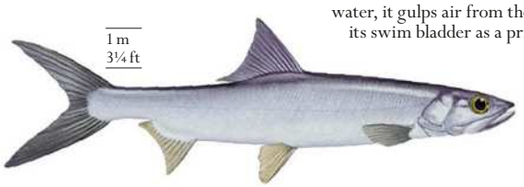
2.5 m
8¼ ft

TARPON
Megalops atlanticus
F: Megalopidae

Found along Atlantic coasts, the tarpon sometimes enters rivers. In stagnant water, it gulps air from the surface using its swim bladder as a primitive lung.

LADYFISH
Elops saurus
F: Elopidae

The ladyfish moves in large schools, close to W. Atlantic shores. When alarmed, it skips over the water's surface.



1 m
3¼ ft

BONYTONGUES AND RELATIVES

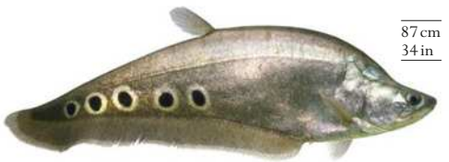
As their name suggests, the fish of the order Osteoglossiformes have many sharp teeth on the tongue and roof of the mouth, which help them to seize and hold prey. These fish live in fresh water, mainly in the tropics. The group has many fish with unusual shapes.

ARAPAIMA
Arapaima gigas
F: Arapaimidae

Weighing up to 200 kg (440 lb), this S. American species is one of the largest freshwater fish. Its swim-bladder acts as a lung and it must gulp air regularly.

ELEPHANTNOSE FISH
Gnathonemus petersii
F: Mormyridae

This African fish finds its way in its murky water habitat by generating weak electrical pulses. Its long lower jaw probes the mud for food.



CLOWN KNIFEFISH
Chitala chitala
F: Notopteridae

This slender, humpbacked fish lives in wetlands of S.E. Asia. In stagnant water, it gulps air and absorbs oxygen from its swim bladder.

EELS

The Anguilliformes have a long, thin, snake-like body with smooth skin, in which the scales are either absent or deeply embedded. The fins are often limited to one long fin runing down the back, around the tail and along the belly. Eels are found in marine and freshwater habitats.

ZEBRA MORAY
Gymnomuraena zebra
F: Muraenidae

This tropical, boldly striped eel has dense pebble-like teeth to eat tough-shelled crabs, molluscs, and sea urchins.

JEWEL MORAY EEL
Muraena lentiginosa
F: Muraenidae

Inhabiting coral reefs in the E. Pacific, this eel rhythmically opens and closes its mouth for respiration.

SPOTTED GARDEN EEL
Heteroconger hassi
F: Congridae

Sandy patches near coral reefs house colonies or "gardens" of this eel. With their tails hidden in burrows, these eels sway like plants, retreating if disturbed.

CONGER EEL
Conger conger
F: Congridae

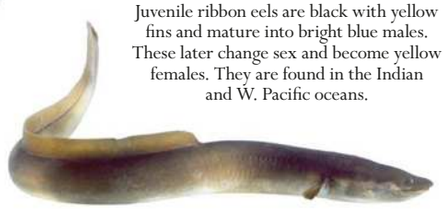
This eel of the North Atlantic and Mediterranean finds an ideal home in shipwrecks. It hides in crevices during the day, emerging mostly at night to hunt other fish.

RIBBON EEL
Rhinomuraena quaesita
F: Muraenidae

Juvenile ribbon eels are black with yellow fins and mature into bright blue males. These later change sex and become yellow females. They are found in the Indian and W. Pacific oceans.

BANDED SNAKE EEL
Myrichthys colubrinus
F: Ophichthidae

Closely resembling a venomous sea snake, this harmless eel of the Indian and W. Pacific oceans is left alone by predators. It searches in sand burrows for small fish.

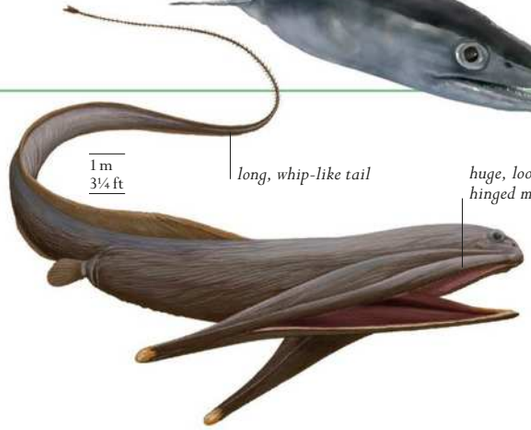


EUROPEAN EEL
Anguilla anguilla
F: Anguillidae

Spending most of its life in fresh water, this endangered, snake-like eel migrates across the Atlantic to the Sargasso Sea to spawn and then die.

SWALLOWERS AND GULPERS

Living in the deep ocean, these bizarre, eel-like fish, belonging to the order Saccopharyngiformes, have no tail fin or pelvic fins, and no scales. They do not have ribs and their large jaws are modified for a wide gape. Like true eels, they are believed to spawn once and then die.

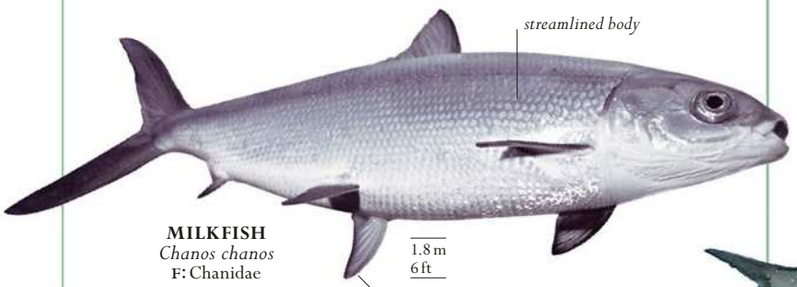


PELICAN GULPER EEL
Eurypharynx pelecanoides
F: Eurypharyngidae

This deep-sea, eel-like fish has huge jaws and an expandable stomach, which enable it to swallow prey almost as large as itself.

MILKFISH AND RELATIVES

With only two exceptions, including the milkfish itself, the Gonorynchiformes live in fresh water. They have a pair of pelvic fins that are set well back on the belly.



MILKFISH
Chanos chanos
F: Chanidae
This fast swimmer has a large forked tail. Feeding solely on plankton, it is farmed in S.E. Asia.

BEAKED SALMON
Gonorynchus greyi
F: Gonorynchidae
Native to Australia and New Zealand, this fish lives in shallow bays and dives headfirst into the sand if threatened.

SARDINES AND RELATIVES

This predominantly marine order includes many commercially important species. The Clupeiformes are silvery, with loose scales, one dorsal fin, a forked tail, and a keel-shaped belly. Most live in large schools and are preyed on by sharks, tuna, and other large fish.

PERUVIAN ANCHOVETA
Engraulis ringens
F: Engraulidae
This tiny plankton-eater lives in enormous shoals along the western coast of S. America, where it is a major source of food for humans, pelicans, and larger fish.

ALLIS SHAD
Alosa alosa
F: Clupeidae
In spring, adults of this migratory species swim from the sea into European rivers to spawn, often swimming very long distances.

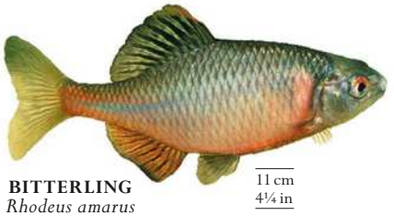
ATLANTIC HERRING
Clupea harengus
F: Clupeidae
Huge shoals of these silvery fish swim in unison eating planktonic copepods. Highly prized, many N.E. Atlantic stocks are very heavily fished.

CARP AND RELATIVES

This is one of the largest freshwater fish orders, with over 4,000 species worldwide. The Cypriniformes have the standard "fish shape", with a single dorsal fin. They typically have large scales. The teeth are in the throat instead of the jaws. Many are familiar aquarium fish, including loaches, minnows, and carp.

CLOWN LOACH
Chromobotia macracanthus
F: Cobitidae
Native to wetlands in S.E. Asia, this loach is a bottom-feeder. It has sharp spines by its eyes, which it uses to defend itself.

TIGER BARB
Puntigrus tetrazona
F: Cyprinidae
Native to the Indonesian islands of Sumatra and Borneo, this fish has been widely introduced elsewhere and is bred for the aquarium trade.



BITTERLING
Rhodeus amarus
F: Cyprinidae
This European fish lays its eggs inside the mantle cavity of a freshwater mussel, where they eventually hatch and the fry escape.

GRASS CARP
Ctenopharyngodon idella
F: Cyprinidae
A native of Asia, this species feeds on aquatic plants. For this reason, it has been introduced in Europe and the USA to keep drainage channels clear of weeds.

GOLDFISH
Carassius auratus
F: Cyprinidae
Originally native to C. Asia and China, the goldfish has been introduced all over the world and there are now many varieties.

COMMON CARP
Cyprinus carpio
F: Cyprinidae
With a mouth that can be thrust out and sensory barbels, a carp finds food by grubbing through the bottom mud. Now introduced worldwide, it was originally from China and C. Europe.

ZEBRAFISH
Danio rerio
F: Cyprinidae
This active little fish spawns frequently and is common in ponds and lakes in S. Asia. It is bred in aquaria and laboratories.

CHARACINS AND RELATIVES

These freshwater fish are mostly carnivores, with well-developed teeth. As well as a normal dorsal fin, most also have a small, fatty adipose fin near the tail. Of the 23 families in the order Characiformes, the piranhas are the most notorious predators.

12 cm
4¾ in

MEXICAN TETRA
Astyanax mexicanus
F: Characidae

While the normal form of the Mexican tetra lives in streams and can see well, this variant lives in cave pools and is blind.

33 cm
13 in

RED PIRANHA
Pygocentrus nattereri
F: Serrasalmidae

Native to S. American rivers, this fish usually eats invertebrates and fish, but schools of them, frenzied by blood, can kill large mammals with their razor-sharp teeth.

6.5 cm
2½ in

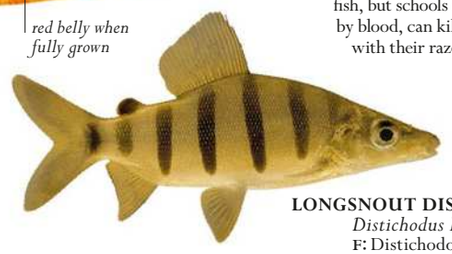
RIVER HATCHETFISH
Gasteropelecus sternicla
F: Gasteropelecidae

This insectivorous S. American fish can leap out of the water to escape predators and to catch aerial prey.

1 m
3¼ ft

TIGERFISH
Hydrocynus vittatus
F: Alestidae

Native to African rivers, this large predator has fang-like teeth and can eat fish half as long as itself.



40 cm
16 in

LONGSNOUT DISTICHODUS
Distichodus lusosso
F: Distichodontidae

Unlike some of its piranha relatives, this is a peaceful herbivorous fish. It lives in streams in equatorial Africa.

CATFISH

The predominantly freshwater catfish have a long body and many whiskery mouth barbels used to help find food. There is a sharp spine in front of the dorsal fin. Most species in this order (Siluriformes) grub around on the bottom searching for algae and small invertebrates.

32 cm
12½ in

STRIPED EEL CATFISH
Plotosus lineatus
F: Plotosidae

Juveniles of this tropical marine species form dense ball-shaped shoals for protection. Solitary adults defend themselves with their venomous fin spines.

1 m
3¼ ft

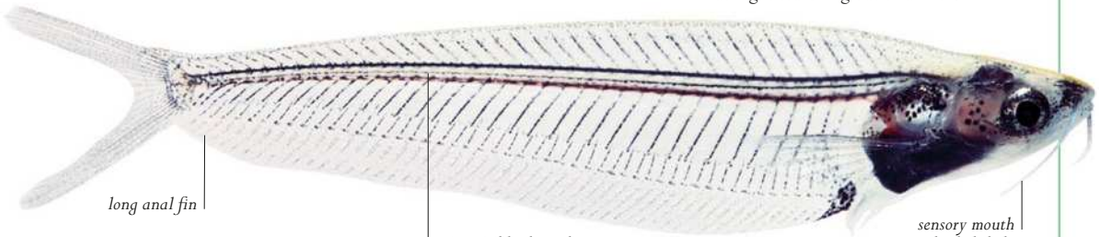
TIGER SHOVELNOSE CATFISH
Pseudoplatystoma fasciatum
F: Pimelodidae

The long barbels of this S. American fish help it find food as it hunts over riverbeds at night searching out small fish.

5 m
16 ft

SHEATFISH
Silurus glanis
F: Siluridae

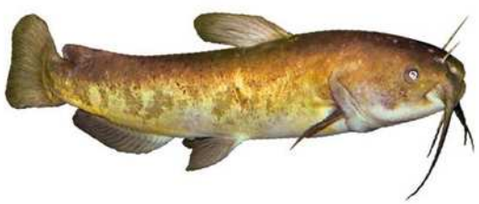
From wetlands in C. Europe and Asia, this huge fish has been known to weigh over 300 kg (660 lb), but due to heavy fishing, none this size exists today.



15 cm
6 in

GLASS CATFISH
Kryptopterus bicirrhis
F: Siluridae

A native of S.E. Asia, this small fish hangs motionless in the water; its transparent body makes it hard for predators to see.



52 cm
20½ in

BROWN BULLHEAD
Ameiurus nebulosus
F: Ictaluridae

This N. American catfish has venomous fin spines that help ward off predators when it is guarding its nest.

SALMON AND RELATIVES

This order of marine and freshwater fish includes many anadromous members (moving from sea to fresh water to breed). Powerful predators, the Salmoniformes have a large tail, a single dorsal fin, and a much smaller adipose fin.

SOCKEYE SALMON
Oncorhynchus nerka
F: Salmonidae
In red breeding colour, this N. Pacific fish migrates into N. American and Asian rivers to spawn and die. The salmon are hunted by brown bears on their difficult journey upriver.

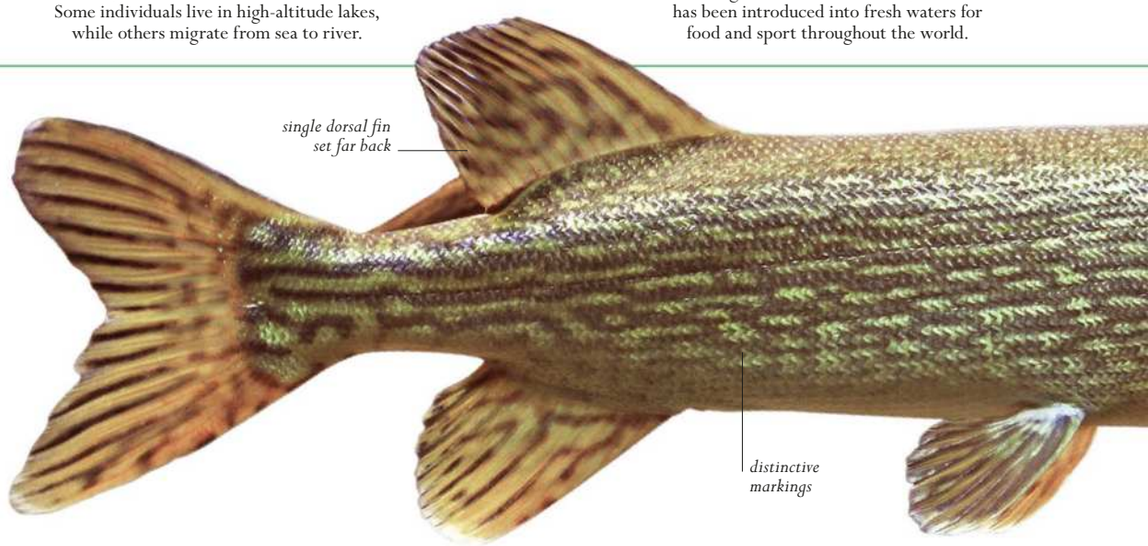
CISCO
Coregonus artedi
F: Salmonidae
Widespread in N. American lakes and large rivers, this fish forms shoals that feed on plankton and invertebrates.

ARCTIC CHAR
Salvelinus alpinus
F: Salmonidae
Clean, cold water is a must for this fish. Some individuals live in high-altitude lakes, while others migrate from sea to river.

RAINBOW TROUT
Oncorhynchus mykiss
F: Salmonidae
Although native to N. America, this fish has been introduced into fresh waters for food and sport throughout the world.

PIKES AND RELATIVES

Found in cool, fresh waters across the northern hemisphere, the Esociformes are fast and agile. The dorsal and anal fins are set far back, near the tail, to give these predatory fish an instant forward thrust.

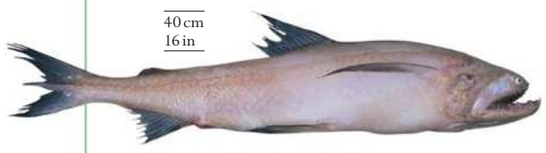


MUD MINNOW
Umbra krameri
F: Umbridae
The European mud minnow is now rare, as the small ditches and canals of its home – the Danube and Dniester river systems – disappear.

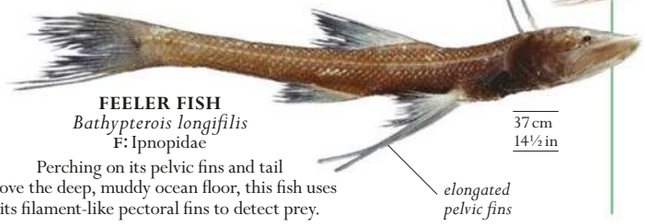
LIZARDFISH AND RELATIVES

This diverse order of marine fish inhabits shallow coastal waters as well as the deep sea. The Aulopiformes have a large mouth, with many small teeth, and can catch large prey. They have a single dorsal fin and a much smaller adipose fin.

VARIEGATED LIZARDFISH
Synodus variegatus
F: Synodontidae
This resident of tropical reefs of the Indian and Pacific oceans perches on a coral head, remaining completely still, and then darts out to catch fish.



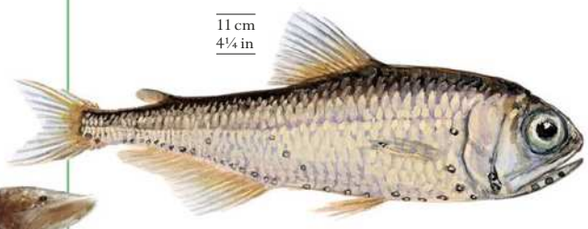
BOMBAY DUCK
Harpadon nehereus
F: Synodontidae
During the monsoon season in the Indo-Pacific, schools of this small fish gather near river deltas to feed on material that is washed down.



FEELER FISH
Bathypterois longifilis
F: Ipnopidae
Perching on its pelvic fins and tail above the deep, muddy ocean floor, this fish uses its filament-like pectoral fins to detect prey.

LANTERNFISH AND RELATIVES

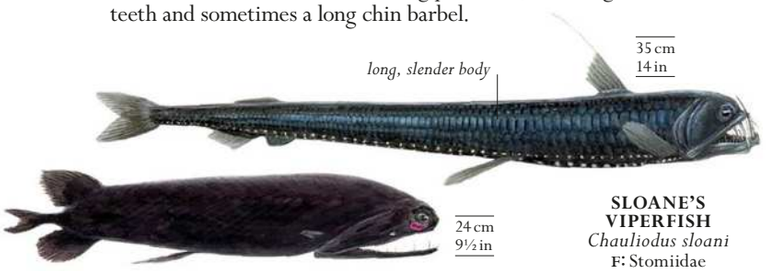
Lanternfish are small, slim fish with many photophores (light organs) that help them communicate in their deep, dark ocean habitat. Members of the order Myctophiformes, these species have large eyes and many migrate towards the surface at night to feed.



SPOTTED LANTERNFISH
Myctophum punctatum
F: Myctophidae
Living in the dark depths of the Atlantic, this lanternfish uses its impressive array of photophores for camouflage as well as communication.

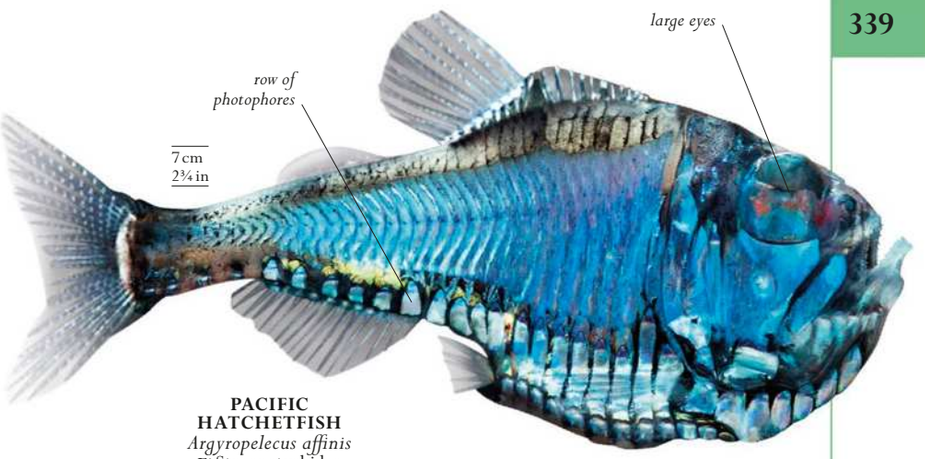
DRAGONFISH AND RELATIVES

A majority of these deep-sea fish have photophores to help them hunt, hide, and find mates. Most members of the order Stomiiformes are fearsome-looking predators, with large teeth and sometimes a long chin barbel.

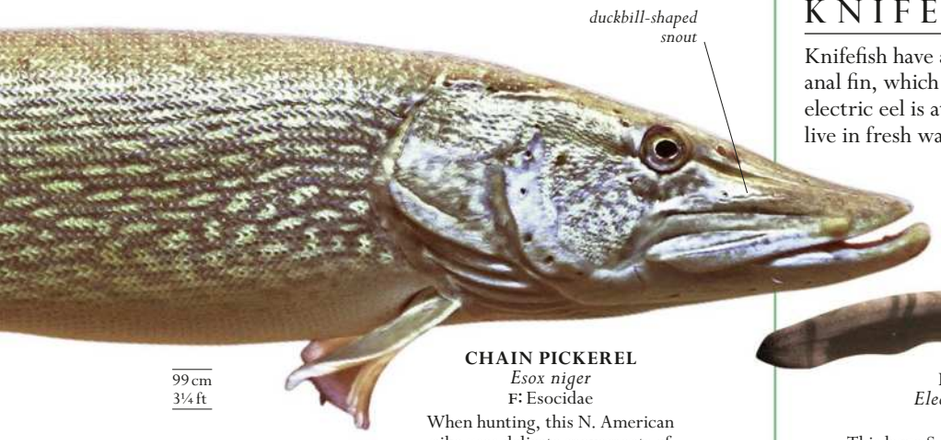


NORTHERN STOPLIGHT LOOSEJAW
Malacosteus niger
F: Stomiidae
Found globally in temperate, tropical, and subtropical oceans, this fish pinpoints its shrimp prey with a beam of red bioluminescent light invisible to the shrimp.

SLOANE'S VIPERFISH
Chauliodus sloani
F: Stomiidae
Viperfish have long, transparent fangs that protrude when the mouth is closed. Light from photophores confuses their prey in the depths of tropical and subtropical oceans.



PACIFIC HATCHETFISH
Argyropelecus affinis
F: Sternoptychidae
The silvery, thin body of this fish helps to camouflage and hide it from predators. It is found in temperate, tropical, and subtropical waters.



CHAIN PICKEREL
Esox niger
F: Esocidae
When hunting, this N. American pike uses delicate movements of its fins to hover motionless before striking with lightning speed.

KNIFEFISH

Knifefish have a sideways flattened, knife-like body, and a single long anal fin, which they use to glide backwards and forwards. The electric eel is atypical, with a long, round body. The Gymnotiformes live in fresh water and can produce electrical impulses.

ELECTRIC EEL
Electrophorus electricus
F: Gymnotidae
This large S. American fish can produce an electric shock of up to 600 volts – enough to kill other fish and stun a human.

BANDED KNIFEFISH
Gymnotus carapo
F: Gymnotidae
Found in murky wetlands in C. and S. America, this fish produces mild electric currents, which it uses to sense its surroundings.

SMELTS AND RELATIVES

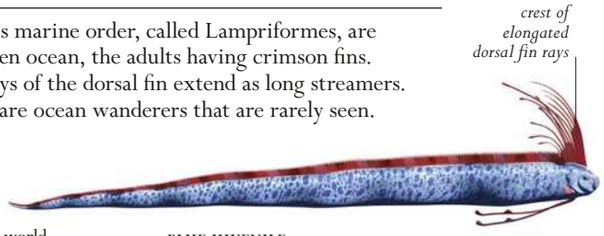
Smelts resemble small, slim salmon and, like them, most have an adipose fin on the back near the tail. Some of the Osmeriformes have a distinctive smell, like the European smelt, which smells like fresh cucumber.

EUROPEAN SMELT
Osmerus eperlanus
F: Opisthoproctidae
Resembling a cross between a herring and a trout, this fish is common in North Sea estuaries. In spring, smelt swim up rivers from the sea to spawn.

CAPELIN
Mallotus villosus
F: Osmeridae
Found in cold Arctic and nearby waters, this small fish forms large shoals that are a crucial food source for many seabirds; its abundance or scarcity determines the breeding success of these birds.

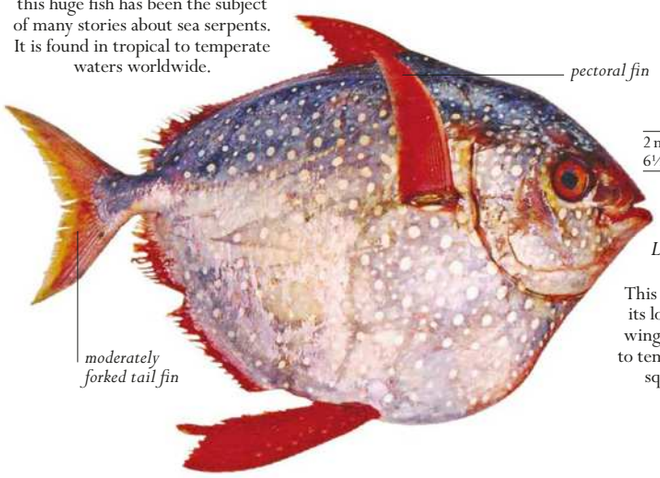
OARFISH AND RELATIVES

The 23 members of this marine order, called Lampriformes, are colourful fish of the open ocean, the adults having crimson fins. In many species, the rays of the dorsal fin extend as long streamers. Most fish in this order are ocean wanderers that are rarely seen.



OARFISH
Regalecus glesne
F: Regalecidae
The longest bony fish in the world, this huge fish has been the subject of many stories about sea serpents. It is found in tropical to temperate waters worldwide.

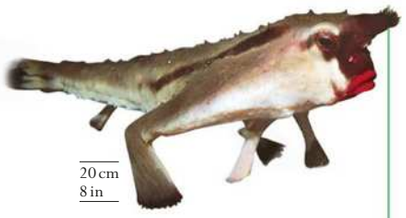
BLUE JUVENILE



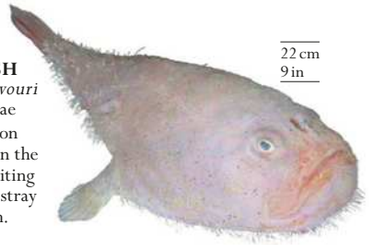
OPAH
Lampris guttatus
F: Lampridae
This rarely seen fish beats its long pectoral fins like wings. Inhabiting tropical to temperate oceans, it eats squid and small fish.

ANGLERFISH AND RELATIVES

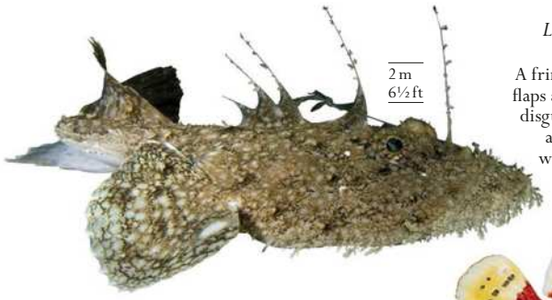
The 376 or so Lophiiformes include some of the most bizarre of all marine fish. A modified fin ray on top of the head acts as a fishing lure (bioluminescent in deep-water species), which attracts prey towards the fish's cavernous mouth.



RED-LIPPED BATFISH
Ogcocephalus darwini
F: Ogcocephalidae
The oddly shaped batfish scrambles over the seabed using its paired pectoral and pelvic fins as props. Its red lips are a mystery.



COFFINFISH
Chaunax endeavouri
F: Chaunacidae
Coffinfish lie on muddy seabeds in the S.W. Pacific, waiting for small fish to stray within reach.



ANGLER
Lophius piscatorius
F: Lophiidae
A fringe of seaweed-shaped flaps around its mouth helps disguise this N.E. Atlantic angler. It can strike with lightning speed.

WARTY FROGFISH
Antennarius maculatus
F: Antennariidae
The well-camouflaged warty frogfish clambers over coral reefs using its limb-like pectoral fins.

FANFIN ANGLER
Caulophryne jordani
F: Caulophrynidae
In the dark ocean depths it is difficult to find a mate. Once successful, the tiny male fanfin angler latches on to the female permanently.

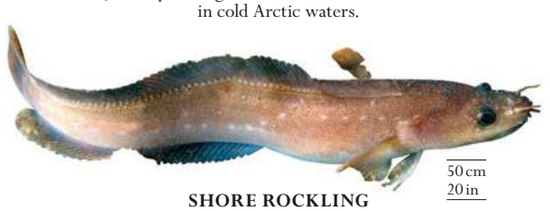
SARGASSUMFISH
Histrio histrio
F: Antennariidae
Whilst most frogfish live on the seabed, this one hides amongst rafts of floating *Sargassum* seaweed, which it closely resembles.

COD AND RELATIVES

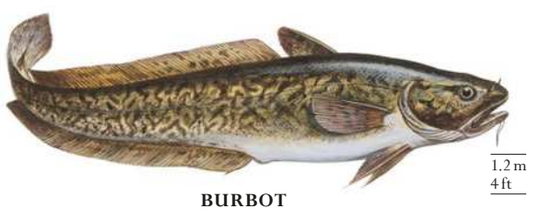
The Gadiformes include many important marine commercial species. Most have two or three soft dorsal fins on their back and many have a chin barbel. Grenadiers live in deep water and have a long thin tail.

ATLANTIC COD
Gadus morhua
F: Gadidae
Overfishing has reduced the average weight of Atlantic cod to 11 kg (24 lb) from a historical maximum weight of over 90 kg (200 lb).

ALASKA POLLOCK
Gadus chalcogrammus
F: Gadidae
The lack of a chin barbel and a protruding lower jaw help distinguish this fish from cod. It lives in cold Arctic waters.



SHORE ROCKLING
Gaidropsarus mediterraneus
F: Lotidae
Equipped with three sensory mouth barbels, this eel-like rockling searches out food in N.E. Atlantic rock pools.



BURBOT
Lota lota
F: Lotidae
Unlike all other Gadiformes, the burbot lives in fresh water. It is found in deep lakes and rivers across the northern hemisphere.

PACIFIC GRENADIER
Coryphaenoides acrolepis
F: Macrouridae
A long scaly tail and bulbous head give this abundant deep-water cod relative its alternative name of Pacific rat-tail.

CUSK EELS

Most members of the order Ophidiiformes live in the ocean and are long, slim, eel-like fish. They have thin pelvic fins and long dorsal and anal fins, which in many species join onto the tail fin.

21 cm
8½ in

PEARLFISH
Carapus acus
F: Carapidae
The adult pearlfish finds refuge inside a sea cucumber, entering tail-first through the anus, exiting at night to feed.

GREY MULLETS

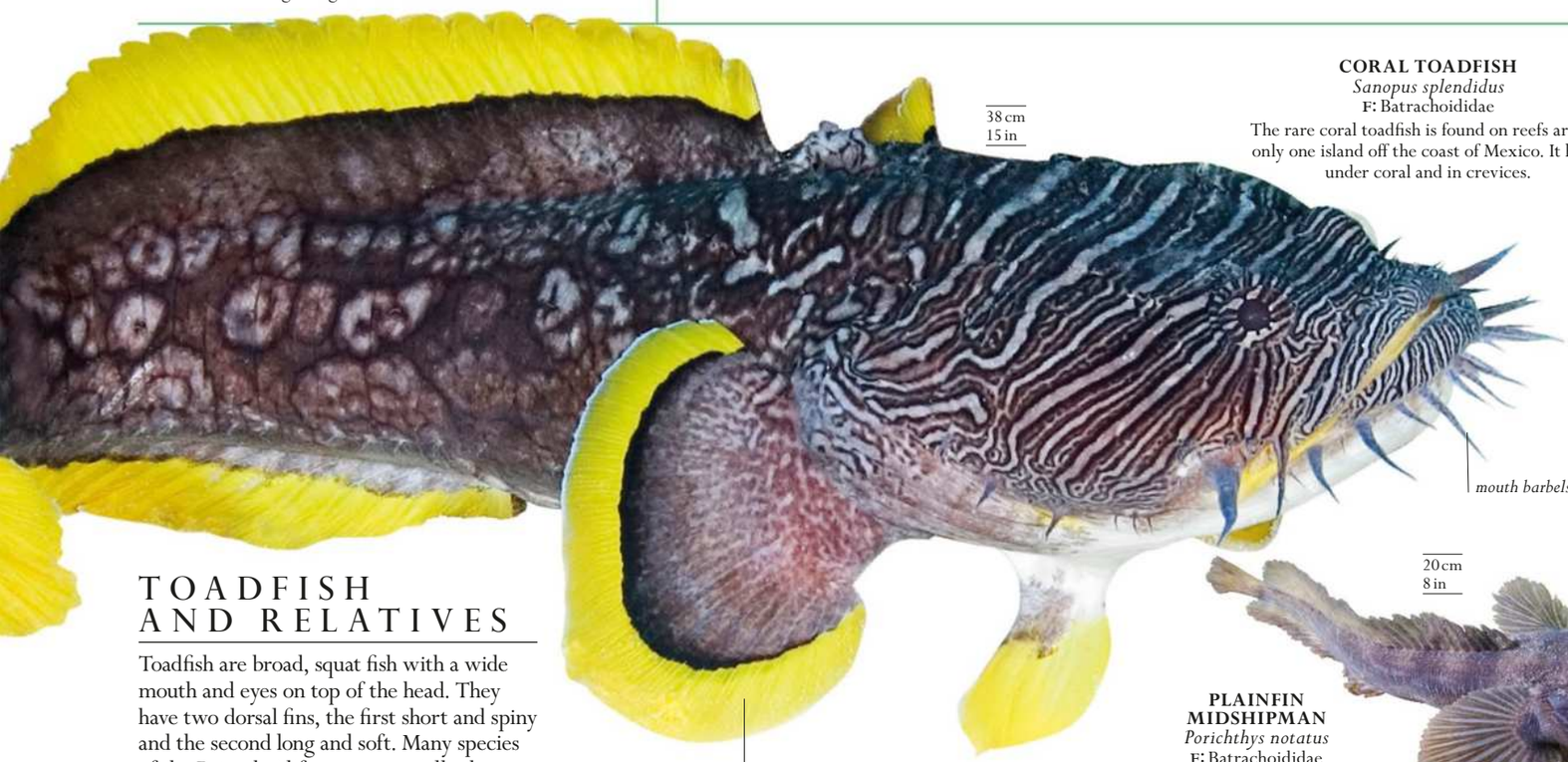
Grey mullets are silvery striped fish with two widely separated dorsal fins; the first has sharp spines, the second has soft rays. Members of the Mugiliformes are distributed worldwide. They are vegetarian, feeding on fine algae and detritus.

75 cm
30 in

GOLDEN GREY MULLET
Liza aurata
F: Mugilidae
Harbours, estuaries, and coastal waters in the N.E. Atlantic are all likely haunts of the this mullet, which often lives in shoals.

TOADFISH AND RELATIVES

Toadfish are broad, squat fish with a wide mouth and eyes on top of the head. They have two dorsal fins, the first short and spiny and the second long and soft. Many species of the Batrachoidiformes, especially the midshipmen, are known for the remarkable way they use their swim bladder to produce sound.



38 cm
15 in

large pectoral fins used for "walking"

mouth barbels

CORAL TOADFISH
Sanopus splendidus
F: Batrachoididae
The rare coral toadfish is found on reefs around only one island off the coast of Mexico. It hides under coral and in crevices.

20 cm
8 in

PLAINFIN MIDSHIPMAN
Porichthys notatus
F: Batrachoididae
Living on the rocky shores along the west coast of N. America, this fish can breathe air to survive when the tide goes out.

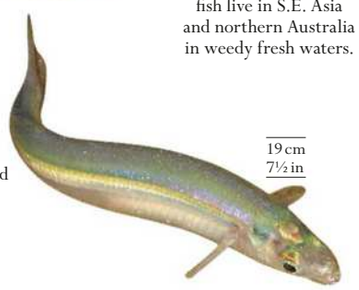
SILVERSIDES AND RELATIVES

These small, slim silvery fish often live in large shoals. There are over 330 Atheriniformes, occuring both in marine and freshwater habitats. Most have two dorsal fins, the first of which has flexible spines, and a single anal fin.

4 cm
1½ in

THREADFIN RAINBOWFISH
Iriatherina werneri
F: Melanotaeniidae
Mature males of this species diplay to females with their long fins. These fish live in S.E. Asia and northern Australia in weedy fresh waters.

CALIFORNIA GRUNION
Leuresthes tenuis
F: Atherinopsidae
Grunion spawn together in thousands depositing eggs in sand on the shore at night during high spring tides.



19 cm
7½ in

NEEDLEFISH AND RELATIVES

With a long, thin, rod-like body and extended beak-like jaws, these silvery fish are well camouflaged in the open ocean. Flying fish – with their large, paired pectoral (side) and pelvic (belly) fins – also belong to this order, the Beloniformes.

93 cm
3 ft

GARFISH
Belone belone
F: Belonidae
Remaining close to the ocean surface in the N.E. Atlantic, this needlefish chases small fish, especially members of the herring family.

ATLANTIC FLYINGFISH
Cheilopogon heterurus
F: Exocoetidae
Pursued by predators or startled by boats, this fish escapes by powering up into the air and gliding away on outspread fins.

40 cm
16 in

KILLIFISH AND RELATIVES

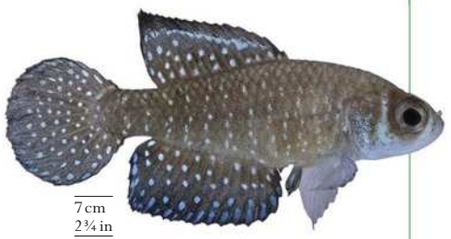
Most members of the Cyprinodontiformes are small freshwater fish with a single dorsal fin and a large tail. Of the ten families, the guppies are perhaps the best known as they produce live young and are popular aquarium fish.

AMIET'S LYRETAIL
Fundulopanchax amieti
F: Nothobranchiidae
This small colourful fish lives in rainforest streams in Cameroon, Africa. There are many other similar species, known collectively as killifish.

FOUREYED FISH
Anableps anableps
F: Anablepidae
The bulging eyes of this S. American fish are divided so that it can see clearly both above and below water.

AMERICAN FLAGFISH
Jordanella floridae
F: Cyprinodontidae
Swamps and streams in Florida are home to this peaceful vegetarian. The male courts a female and guards their eggs.

BLACK PEARLFISH
Austrolebias nigripinnis
F: Rivulidae
Subtropical rivers in S. America are home to this species and all the other members of its colourful family.



SAILFIN MOLLY
Poecilia latipinna
F: Poeciliidae
The large dorsal fin of this N. American fish is displayed in courtship. The female bears live young.

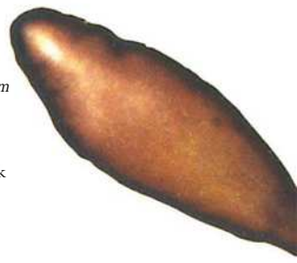
SQUIRRELFISH AND ROUGHIES

These marine fish are deep-bodied with large scales, a forked tail, and sharp fin spines. Most of these fish (Beryciformes and Trachichthyiformes) are nocturnal and are often a red colour – a good disguise at night. Red light is absorbed first by water and red fish appear black below a certain depth.

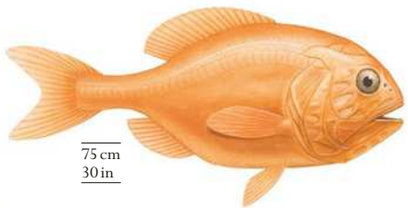
CROWN SQUIRRELFISH
Sargocentron diadema
F: Holocentridae
This is a typical squirrelfish and one of many similar species found on tropical reefs. By day it hides in crevices.

PINEAPPLEFISH
Cleidopus gloriamaris
F: Monocentridae
Few predators would attack this spiny fish, which has an armour of thick scales. Its colour warns that it is unpalatable.

EYELIGHT FISH
Photoblepharon palpebratum
F: Anomalopidae
At night this fish signals to others using a light organ under each eye. It has a black membrane that it uses to cover the light, creating a flashing effect.



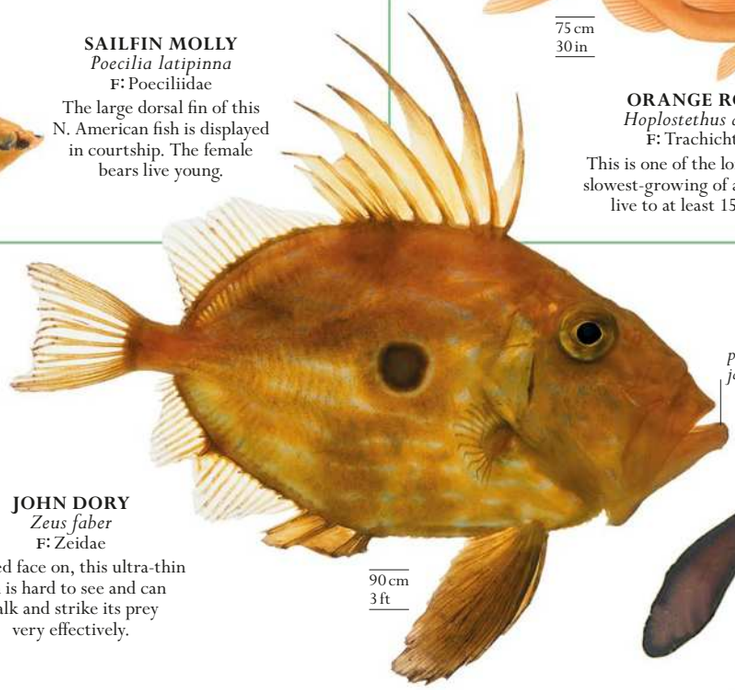
COMMON FANGTOOTH
Anoplogaster cornuta
F: Anoplogastridae
The huge fangs of this deep-ocean predator make escape impossible for its prey, which it swallows whole.



ORANGE ROUGHY
Hoplostethus atlanticus
F: Trachichthyidae
This is one of the longest-lived and slowest-growing of any fish and can live to at least 150 years old.

DORIES AND RELATIVES

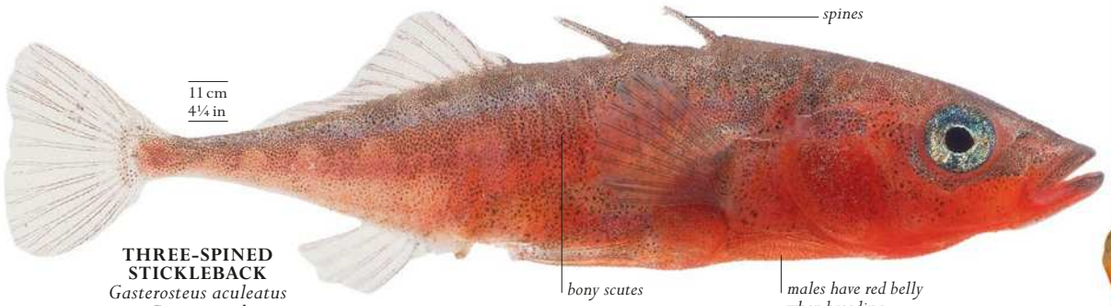
The 41 species belonging to the order Zeiformes are all marine, deep-bodied, but thin fish with long dorsal and anal fins. Dories have protrusible jaws – they can be shot out to capture prey. They feed on a wide range of small fish that they stalk head on.



JOHN DORY
Zeus faber
F: Zeidae
Viewed face on, this ultra-thin fish is hard to see and can stalk and strike its prey very effectively.

STICKLEBACKS AND SEAMOTHS

Most sticklebacks inhabit still and slow-moving fresh water, but some live in the sea as do seamoths. The Gasterosteiformes have a long, thin, stiff body protected by bony scutes (plates) along the sides and sharp spines along the back.



THREE-SPINED STICKLEBACK
Gasterosteus aculeatus
F: Gasterosteidae
This little fish is widespread in fresh water and shallow seas in the northern hemisphere. The male performs an elaborate courtship dance.

SEAMOTH
Eurypegasus draconis
F: Pegasidae
Unlike the closely related sticklebacks, the tropical marine seamoth is flat and has large wing-like pectoral (side) fins.

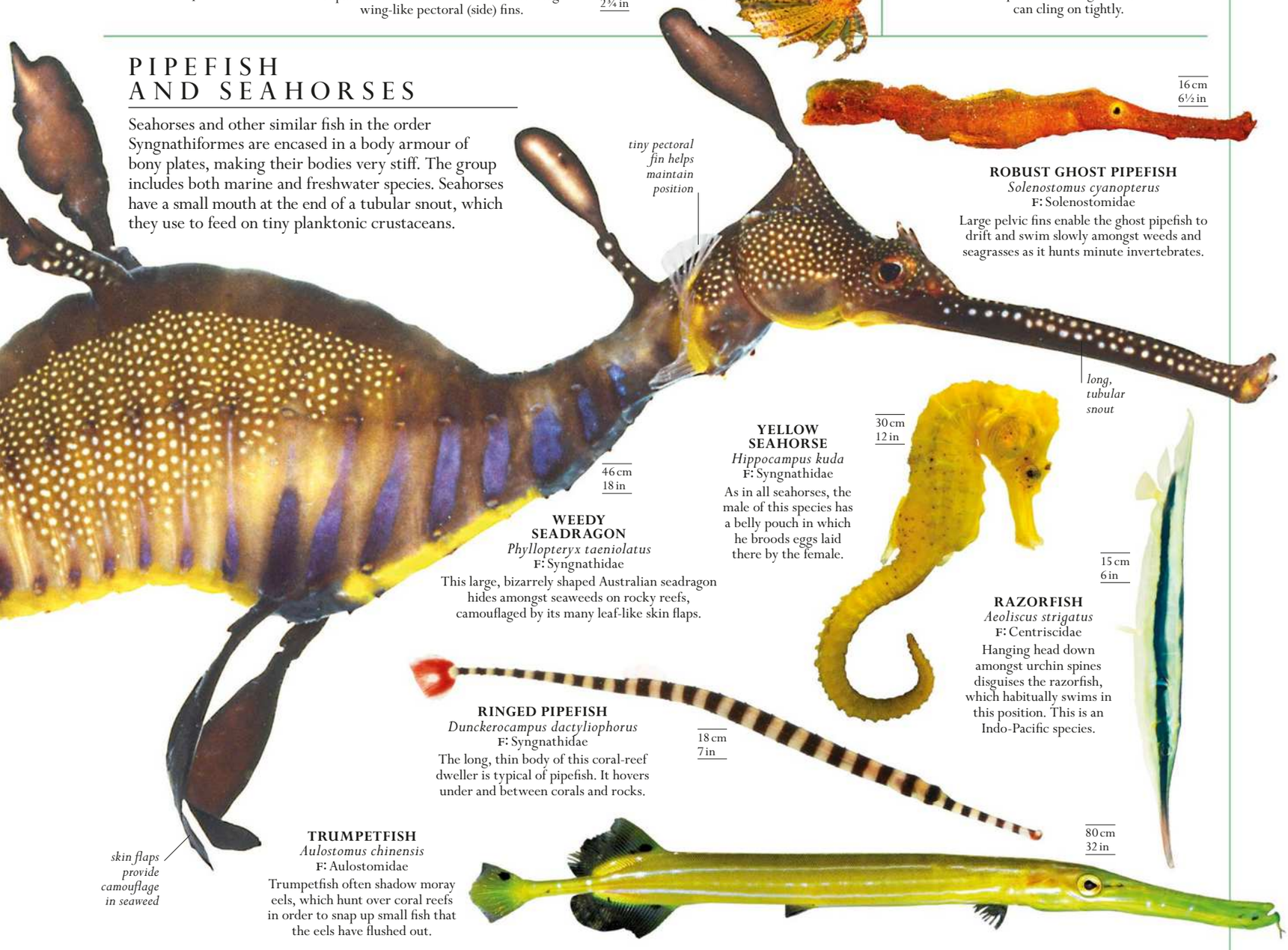
CLINGFISH AND RELATIVES

Clingfish are small, usually marine, bottom-dwelling fish. Most of the Gobiesociformes possess a sucker formed from modified pelvic fins with which they cling to rocks. Their eyes are set high on the head and they have one dorsal fin.

CONNEMARA CLINGFISH
Lepadogaster candolii
F: Gobiesocidae
Living in rocky shallows in the N.E. Atlantic, this little fish is exposed to strong waves, but can cling on tightly.

PIPEFISH AND SEAHORSES

Seahorses and other similar fish in the order Syngnathiformes are encased in a body armour of bony plates, making their bodies very stiff. The group includes both marine and freshwater species. Seahorses have a small mouth at the end of a tubular snout, which they use to feed on tiny planktonic crustaceans.



ROBUST GHOST PIPEFISH
Solenostomus cyanopterus
F: Solenostomidae
Large pelvic fins enable the ghost pipefish to drift and swim slowly amongst weeds and seagrasses as it hunts minute invertebrates.

YELLOW SEAHORSE
Hippocampus kuda
F: Syngnathidae
As in all seahorses, the male of this species has a belly pouch in which he broods eggs laid there by the female.

WEEDY SEADRAGON
Phyllopteryx taeniolatus
F: Syngnathidae
This large, bizarrely shaped Australian seadragon hides amongst seaweeds on rocky reefs, camouflaged by its many leaf-like skin flaps.

RAZORFISH
Aeoliscus strigatus
F: Centriscidae
Hanging head down amongst urchin spines disguises the razorfish, which habitually swims in this position. This is an Indo-Pacific species.

RINGED PIPEFISH
Dunckerocampus dactyliophorus
F: Syngnathidae
The long, thin body of this coral-reef dweller is typical of pipefish. It hovers under and between corals and rocks.

TRUMPETFISH
Aulostomus chinensis
F: Aulostomidae
Trumpetfish often shadow moray eels, which hunt over coral reefs in order to snap up small fish that the eels have flushed out.

SWAMPEELS AND RELATIVES

These tropical and subtropical freshwater fish have an eel-like body and most Synbranchiformes have tiny or no fins. This makes it easy for them to slither through swamps and marshes and burrow in mud.

FIRE EEL
Mastacembelus erythrotaenia
F: Mastacembelidae
Living in flooded lowland plains and slow rivers in S.E. Asia, this edible spiny eel feeds on insect larvae and worms.

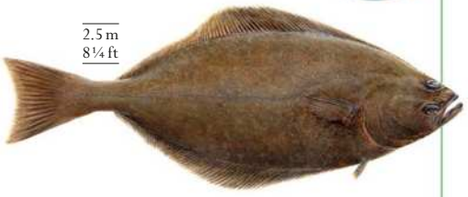
MARBLED SWAMPEEL
Synbranchus marmoratus
F: Synbranchidae
Able to breathe air if necessary, this almost finless fish survives in very small bodies of water in C. and S. America.

FLATFISH

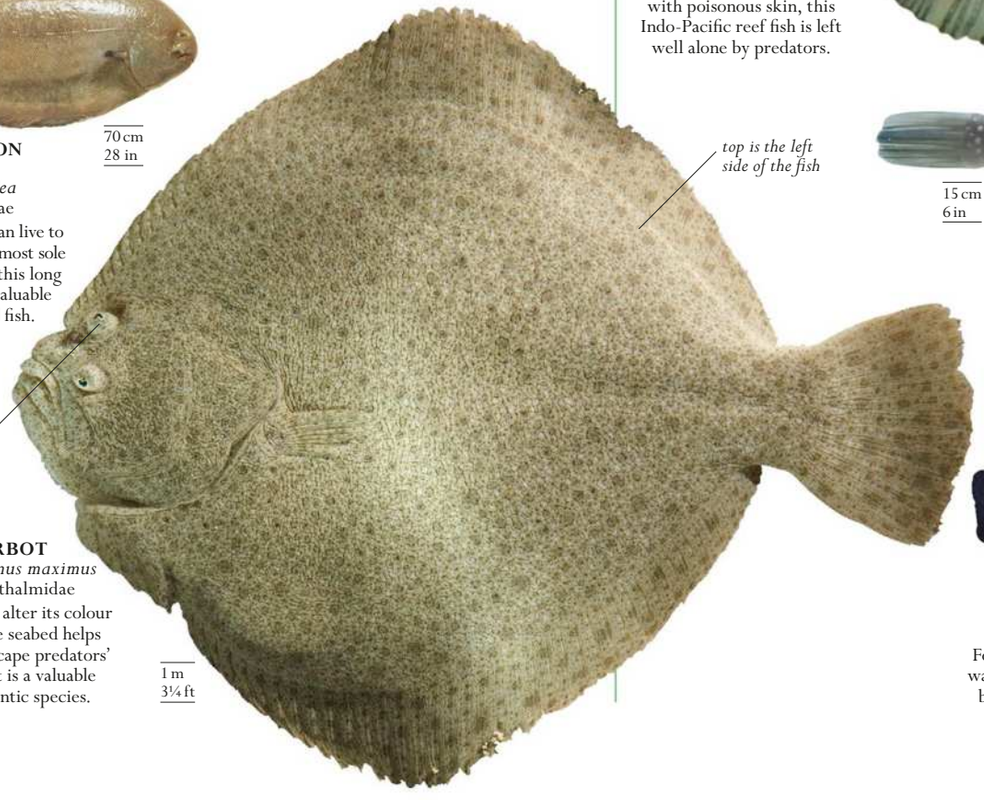
Pleuronectiformes start life in the plankton as normal upright juveniles. As they grow, they become flattened sideways and lie on one side on the seabed. The underneath eye migrates round to join the other on the upper side.

EUROPEAN PLAICE
Pleuronectes platessa
F: Pleuronectidae
This North Atlantic commercial flatfish lies camouflaged on the seabed with its right side uppermost. It emerges at night to feed.

ATLANTIC HALIBUT
Hippoglossus hippoglossus
F: Pleuronectidae
One of the largest flatfish, the Atlantic halibut lies on its left side with both eyes on the upward-facing right side.



COMMON SOLE
Solea solea
F: Soleidae
Although they can live to be 30 years old, most sole do not survive this long as they are a valuable commercial fish.

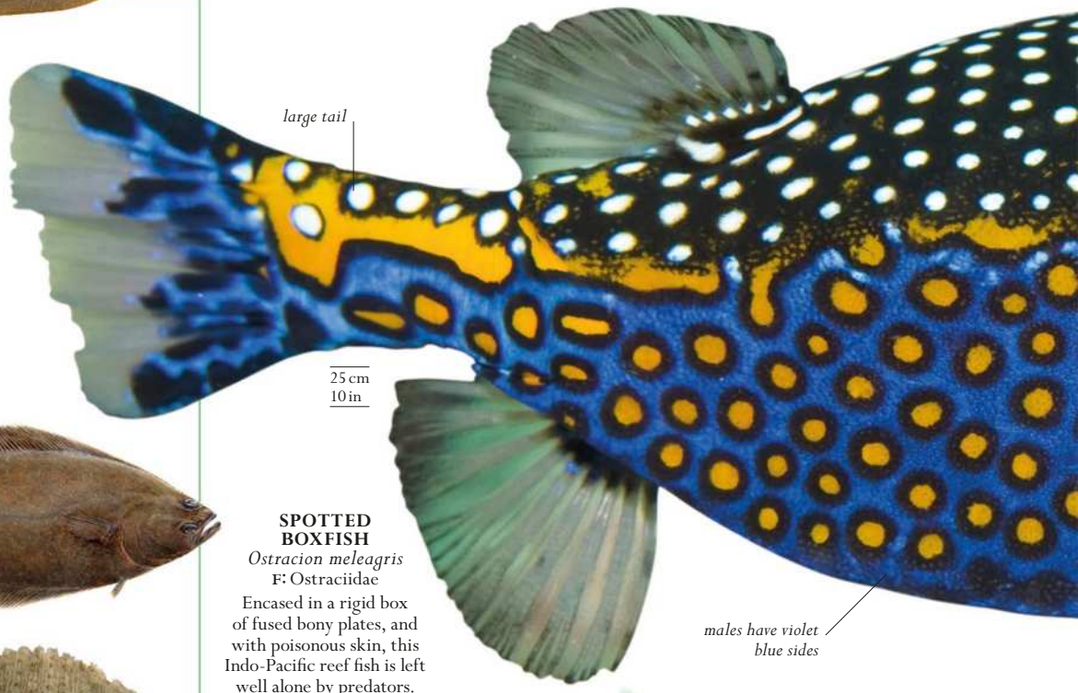


TURBOT
Scophthalmus maximus
F: Scophthalmidae
The ability to alter its colour to match the seabed helps the turbot escape predators' attention. It is a valuable North Atlantic species.

TRIGGERFISH, PUFFERFISH, AND RELATIVES

This diverse group of marine and freshwater fish includes the huge ocean sunfish and the poisonous pufferfish. Instead of normal teeth, the Tetraodontiformes have fused tooth plates or just a few large teeth. Their scales are modified to form protective spines or plates.

CLOWN TRIGGERFISH
Balistoides conspicillum
F: Balistidae
This brightly coloured coral-reef fish can wedge itself in a crevice by erecting its dorsal spines, which lock in position.



SPOTTED BOXFISH
Ostracion meleagris
F: Ostraciidae
Encased in a rigid box of fused bony plates, and with poisonous skin, this Indo-Pacific reef fish is left well alone by predators.

WHITE-SPOTTED PUFFER
Arothron hispidus
F: Tetraodontidae
The neurotoxin contained within the skin and organs of this fish can easily kill a human and deters natural predators.

LONG-SPINE PORCUPINEFISH
Diodon holocanthus
F: Diodontidae
Found in all tropical seas, this spiny fish can suck in water to inflate its body and turn itself into a prickly ball – a very effective deterrent against predators.

SCORPIONFISH AND RELATIVES

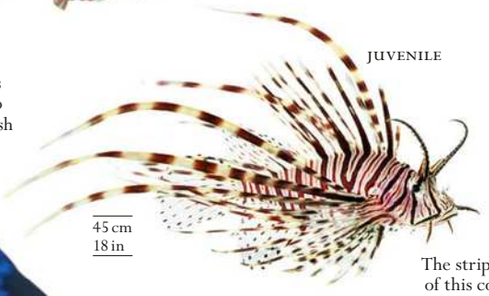
Mostly bottom-living and marine, fish in this large order have a large spiny head with a unique bony strut across the cheek. Most Scorpaeniformes have sharp, sometimes venomous spines in their dorsal fins and many are camouflage experts.

MIMIC FILEFISH
Paraluteres prionurus
F: Monacanthidae

The mimic filefish is avoided by predators because it closely resembles the saddled pufferfish, which has toxic flesh.

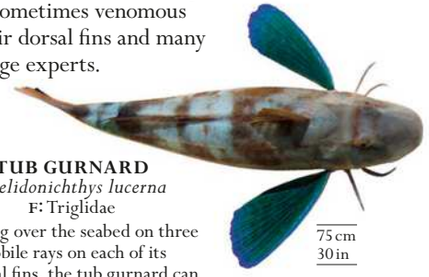
SMALLSCALED SCORPIONFISH
Scorpaena porcus
F: Scorpaenidae

Well concealed by skin flaps on the head and its ability to change colour, the scorpionfish is hard to spot.



RED LIONFISH
Pterois volitans
F: Scorpaenidae

The striped colours warn predators that even juveniles of this coral-reef fish have venomous dorsal fin spines. Adults darken with age and can be almost black.



TUB GURNARD
Chelidonichthys lucerna
F: Triglidae

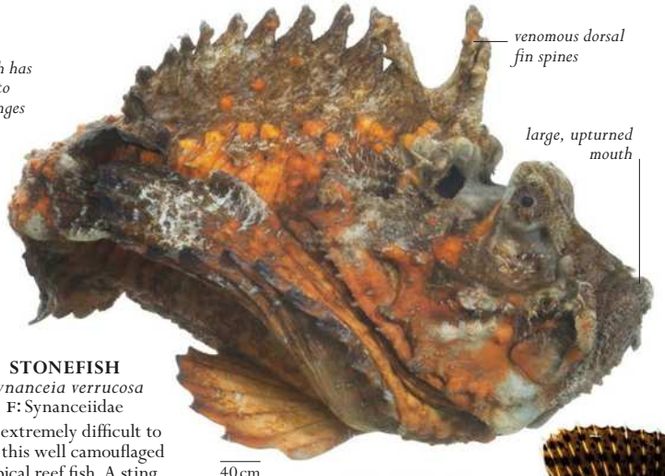
Walking over the seabed on three mobile rays on each of its pectoral fins, the tub gurnard can probe for hidden invertebrates.

LUMPSUCKER
Cyclopterus lumpus
F: Cyclopteridae

A strong sucker on the belly allows this rotund North Atlantic fish to cling onto wave-battered rocks and guard its eggs.

BIG BAIKAL OILFISH
Comephorus baikalensis
F: Comephoridae

About a quarter of the body of this fish is oil, which provides it with buoyancy. It is endemic to Lake Baikal, Russia.

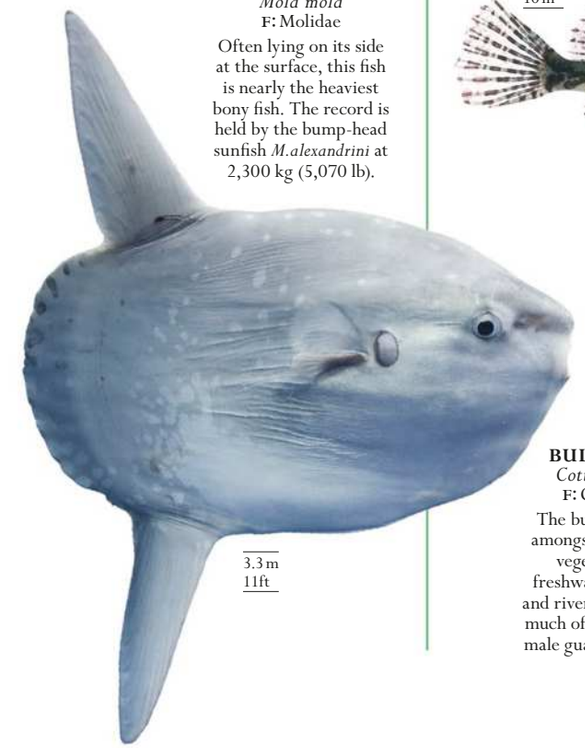


STONEFISH
Synanceia verrucosa
F: Synanceiidae

It is extremely difficult to spot this well camouflaged tropical reef fish. A sting from its venomous spines can be fatal to humans.

LONGSPINED BULLHEAD
Taurulus bubalis
F: Cottidae

The colour of this coastal and shore fish varies widely, according to its background. For example, fish living amongst red seaweeds are red.



OCEAN SUNFISH
Mola mola
F: Molidae

Often lying on its side at the surface, this fish is nearly the heaviest bony fish. The record is held by the bump-head sunfish *M.alexandrini* at 2,300 kg (5,070 lb).

BULLHEAD
Cottus gobio
F: Cottidae

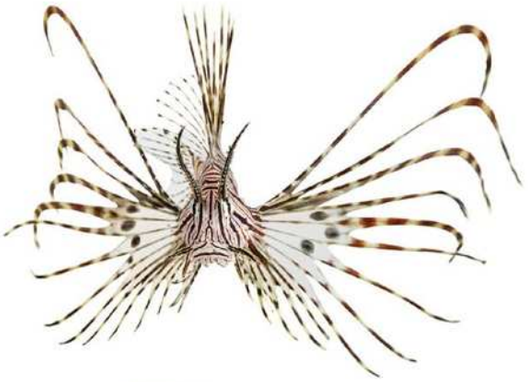
The bullhead lives amongst stones and vegetation in freshwater streams and rivers throughout much of Europe. The male guards the eggs.

FLYING GURNARD
Dactylopterus volitans
F: Dactylopteridae

This species uses its huge fan-like pectoral fins to "fly" through the water. It "takes off" from the seabed if disturbed.

RED LIONFISH
Pterois volitans

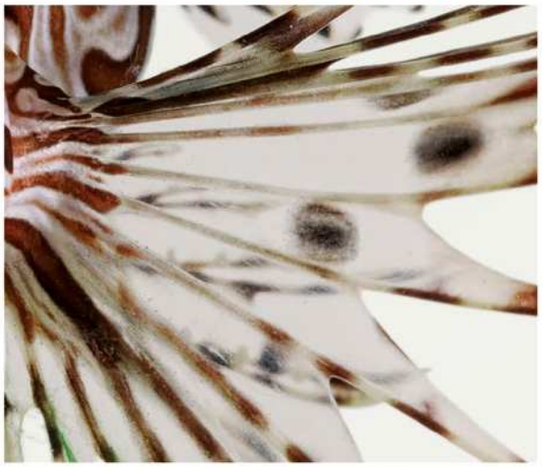
The red lionfish is a night hunter, patrolling tropical coral and rocky reefs in the western Pacific in search of small fish and crustaceans. It corrals its prey against the reef by spreading out its wide pectoral fins – one on each side of its body – before gulping in the prey with lightning speed. Sometimes it stalks its prey out in the open, relying on stealth and a final quick rush, similar to a lion hunting on an African plain. Protected by venomous spines, it will often face a diver or potential predator head-on if approached. One male may collect a small harem of females and will charge other males that stray too close. When ready to spawn, the male displays to the female, circling round her before they swim up towards the surface to shed eggs and sperm into the water. After a few days the eggs hatch into planktonic larvae that drift in the plankton for about a month before settling on the seabed.



SIZE 45 cm (18 in) in length
HABITAT Coral and rock reefs
DISTRIBUTION Pacific Ocean, introduced into W. Atlantic
DIET Fish and crustaceans

> VIBRANT WARNING
The contrasting striped pattern of the red lionfish acts as a warning to predators that the fish is venomous and they should keep away. On land, stinging wasps use a similar method to avoid being eaten.

< MENACING PREDATOR
This efficient predator has been released from aquariums into the Caribbean, where it is a threat to native reef fish. It hunts at dusk using its large eyes and acute sense of smell.



^ VARIED STRIPES
The striped pattern differs between individuals, and becomes much less obvious in breeding males, which can be very dark.

eye is disguised by a dark stripe that confuses potential predators

head tentacle

< PECTORAL FINS
The soft rays of the pectoral fins are joined together for part of their length by a fine membrane, which is marked with circular splotches of colour.

fleshy "whiskers" may help disguise the fish's large, open mouth when approaching prey

VENOMOUS SPINES >
Sharp spines in this fish's dorsal, anal, and pelvic fins can be used to inject venom that causes extreme pain in humans, but is rarely fatal. The spines are purely defensive.

< TAIL UP
Lionfish often hang slightly head down and tail up, ready to pounce on passing prey. The tail helps the fish to maintain this position, rather than to swim fast.

dorsal fin made up of sharp spines
wide rays of pectoral fins spread out fully when the lionfish ambushes prey
tail
anal fin

PERCH AND RELATIVES

With at least 162 families and over 11,500 species, the Perciformes form the largest and most diverse vertebrate order. Most have both spines and soft rays in their dorsal and anal fins. The pelvic fins are set well forward, close to the pectoral fins. New research means that some families included here are likely to be moved into existing or new orders.

LONGFIN SPADEFISH
Platax teira
F: Ephippidae
Living on coral reefs in the Indo-Pacific, this flattened species patrols in small groups, feeding on algae and invertebrates.

FOURSPOT BUTTERFLYFISH
Chaetodon quadrimaculatus
F: Chaetodontidae
Many different species of butterflyfish are found on coral reefs around the world. This fish lives in the W. Pacific.

BLUE-SPOTTED SEABREAM
Pagrus caeruleostictus
F: Sparidae
Found in the E. Atlantic, this is a typical seabream with a steep head profile, forked tail, and long dorsal fin.

RED BANDFISH
Cepola macrophthalma
F: Cepolidae
Living in vertical mud burrows in the N.E. Atlantic, the red bandfish feeds on passing plankton.

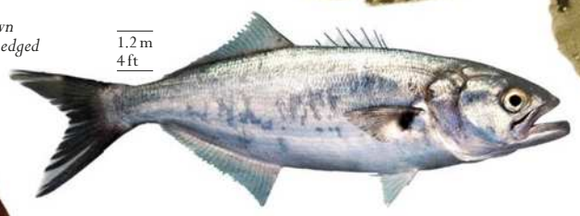
OCHRE-STRIPED CARDINALFISH
Ostorhinchus compressus
F: Apogonidae
This coral-reef resident of the W. Pacific is a small, nocturnal species with two dorsal fins and large eyes. The male incubates the eggs in his mouth.

RED MULLET
Mullus surmuletus
F: Mullidae
Common in the Mediterranean and N.E Atlantic, this species detects buried prey with its mobile barbels. It is a relative of the tropical goatfish.

GREEN SUNFISH
Lepomis cyanellus
F: Centrarchidae
Well known in N. America, this large species is one of the most common fish in lakes and rivers.

BANDED ARCHERFISH
Toxotes jaculatrix
F: Toxotidae
Living mainly in brackish mangrove estuaries in S.E. Asia, Australia, and the W. Pacific, this fish catches insects from overhanging branches by shooting a jet of water from its mouth.

HARLEQUIN SWEETLIPS
Plectorhinchus chaetodonoides
F: Haemulidae
The adult harlequin sweetlips is cream with black spots. The colour and movement of the juvenile shown here mimics a toxic flatworm.



BLUEFISH
Pomatomus saltatrix
F: Pomatomidae
This widespread, voracious, and aggressive predator roams tropical and subtropical oceans in schools that herd and attack smaller fish.

EUROPEAN PERCH
Perca fluviatilis
F: Percidae
Native to Europe and Asia, this widespread, predatory freshwater fish has been introduced as a sport fish for anglers in Australia and elsewhere, where it has become a pest.

YELLOWHEAD JAWFISH
Opistognathus aurifrons
F: Opistognathidae
After the female of this Caribbean fish has laid her eggs, the male broods them in his mouth.

40 cm
16 in

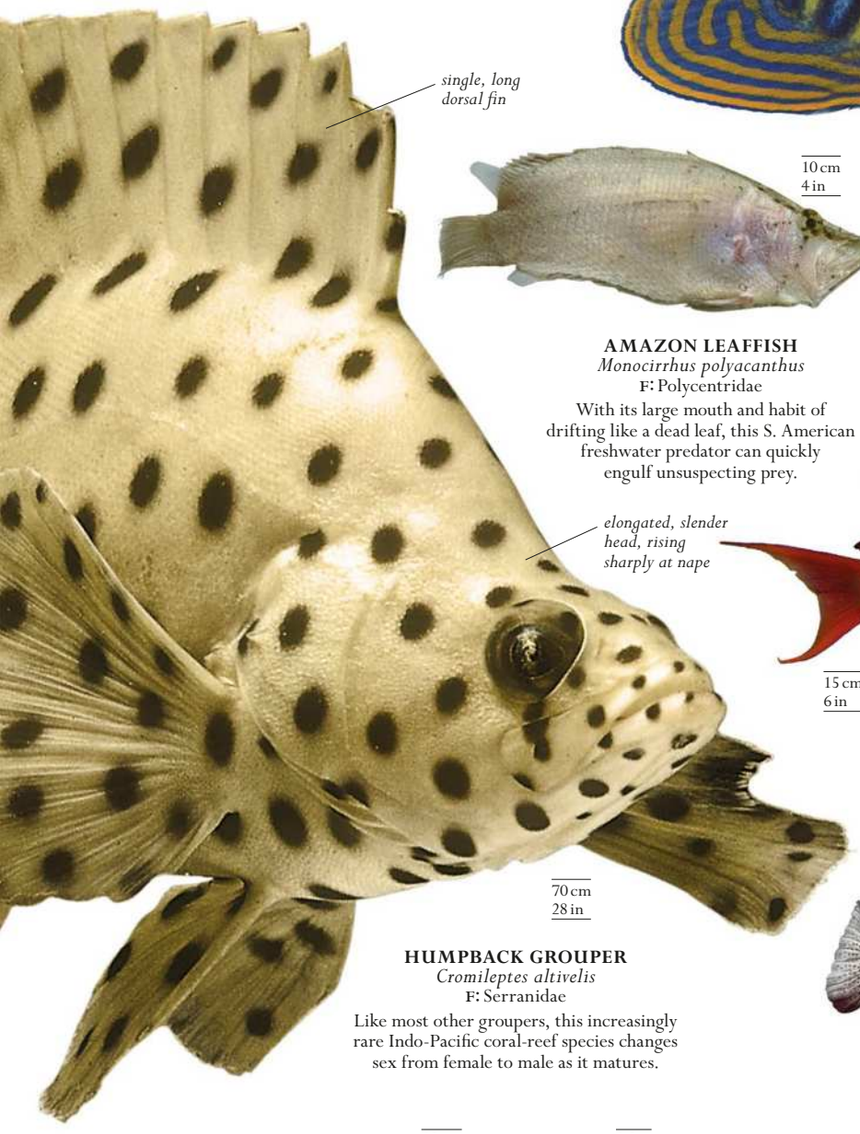
EMPEROR ANGELFISH
Pomacanthus imperator
F: Pomacanthidae

This species lives on coral reefs in the Indo-Pacific. Juveniles and adults have different patterns, which protects juveniles from territorial aggression by adults.

25 cm
10 in

ROYAL ANGELFISH
Pygoplites diacanthus
F: Pomacanthidae

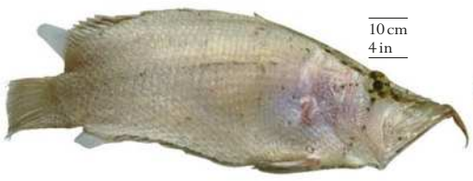
The striking colours of the royal angelfish and of other coral reef fish help recognition and communication between species.



70 cm
28 in

HUMPBACK GROUPER
Cromileptes altivelis
F: Serranidae

Like most other groupers, this increasingly rare Indo-Pacific coral-reef species changes sex from female to male as it matures.



10 cm
4 in

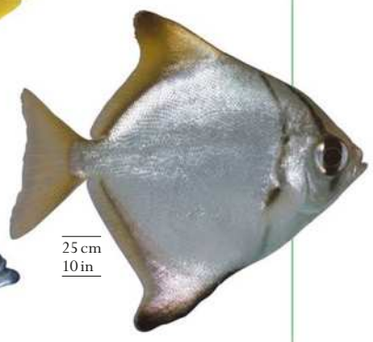
AMAZON LEAFFISH
Monocirrhus polyacanthus
F: Polycentridae

With its large mouth and habit of drifting like a dead leaf, this S. American freshwater predator can quickly engulf unsuspecting prey.

2 m
6½ ft

WRECKFISH
Polyprion americanus
F: Polyprionidae

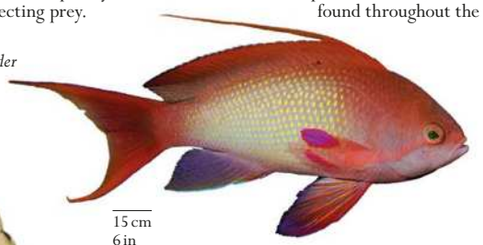
Young wreckfish live a nomadic life among surface-drifting debris, while the adults favour shipwrecks, caves, and rocky areas. They are found throughout the world's oceans.



25 cm
10 in

SILVER MOONY
Monodactylus argenteus
F: Monodactylidae

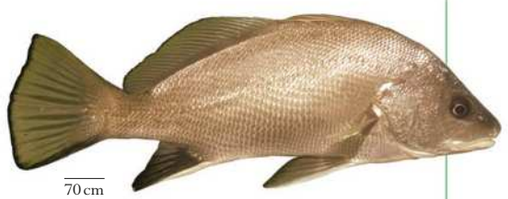
This flattened Indo-Pacific species is most at home in brackish-water estuaries, where it swims in small shoals.



15 cm
6 in

SEA GOLDIE
Pseudanthias squamipinnis
F: Serranidae

This small fish gathers plankton from the waters near steep coral cliffs and ledges. The males defend a harem of females.



70 cm
28 in

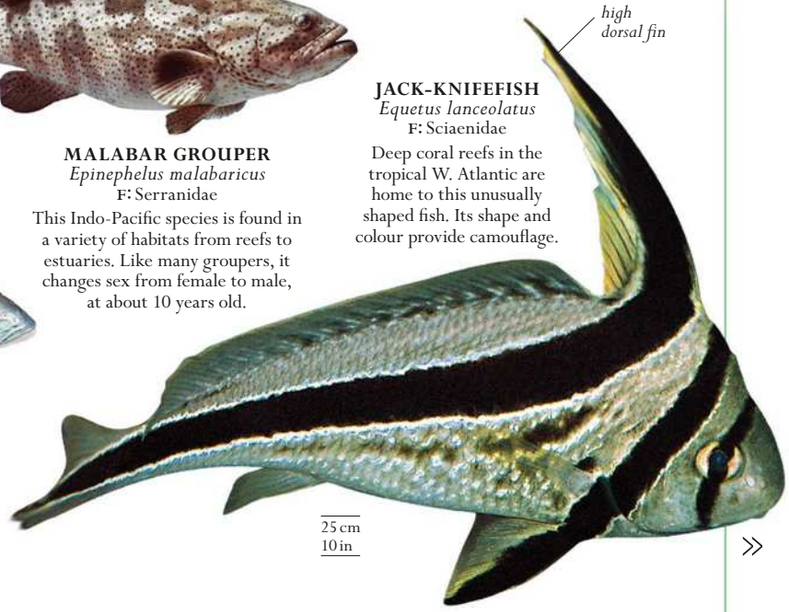
BROWN MEAGRE
Sciaena umbra
F: Sciaenidae

Belonging to a family known as drums and croakers, this fish of the N.E. Atlantic and Mediterranean communicates with loud sounds generated by its swim bladder.

1.2 m
4 ft

MALABAR GROUPER
Epinephelus malabaricus
F: Serranidae

This Indo-Pacific species is found in a variety of habitats from reefs to estuaries. Like many groupers, it changes sex from female to male, at about 10 years old.



25 cm
10 in

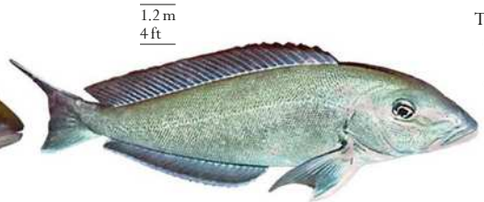
JACK-KNIFEFISH
Equetus lanceolatus
F: Sciaenidae

Deep coral reefs in the tropical W. Atlantic are home to this unusually shaped fish. Its shape and colour provide camouflage.

40 cm
16 in

COMMON BLUESTRIPE SNAPPER
Lutjanus kasmira
F: Lutjanidae

This fast-swimming snapper forms shoals in coral reefs during the day, dispersing at night to feed.



1.2 m
4 ft

GREY TILEFISH
Caulolatilus microps
F: Malacanthidae

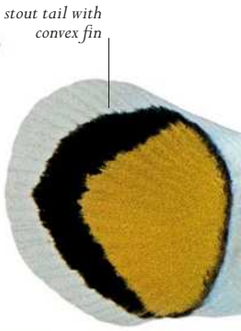
Living in mud and sand off the east coast of N. America, this fish mostly remains within a depth of 200 m (655 ft) to avoid very cold water.

»

» PERCH AND RELATIVES

SMALL SANDEEL
Ammodytes tobianus
F: Ammodytidae

This and other small sandeel species are vital food source for seabirds. It is found in large shoals in shallow sandy bays of the N.E. Atlantic Ocean.



WOLF-FISH
Anarhichas lupus
F: Anarhichadidae

A large mouth and strong teeth enable this North Atlantic species to tackle hard-shelled invertebrates.

LESSER WEEVERFISH
Echiichthys vipera
F: Trachinidae

This venomous N.E. Atlantic fish lies buried in the sand and can inflict a painful sting from its spiny, black, first dorsal fin.

BLACK SWALLOWER
Chiasmodon niger
F: Chiasmodontidae

Found in deep tropical and subtropical waters, where food is scarce, this fish, with its huge mouth and distendable stomach, can tackle prey larger than itself.

CUCKOO WRASSE
Labrus mixtus
F: Labridae

Blue-marked males of the species (shown here) develop from large, pink females with black and white tail markings, who change both colour and sex. This fish is found in the N.E. Atlantic and Mediterranean.

HARLEQUIN TUSKFISH
Choerodon fasciatus
F: Labridae

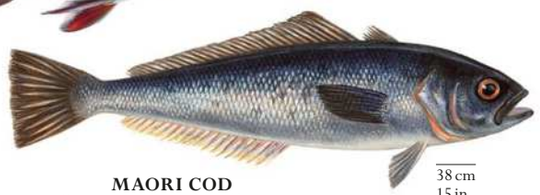
This member of the wrasse family from the W. Pacific uses its protruding canine-like teeth to move stones in its search for invertebrate prey.

CLEANER WRASSE
Labroides dimidiatus
F: Labridae

This tiny wrasse forms a mutualistic relationship with other reef fish. It cleans and eats parasites off these fish at specially set up "cleaner stations" on the reef.

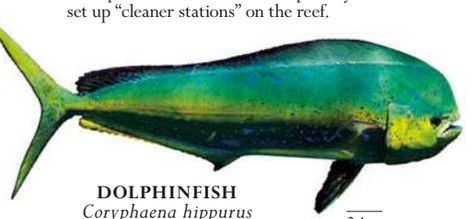
ANTARCTIC TOOTHFISH
Dissostichus mawsoni
F: Nototheniidae

Like many Southern Ocean fish, this species grows slowly, eventually reaching a large size. Its blood contains natural antifreeze, which helps it to survive icy waters.



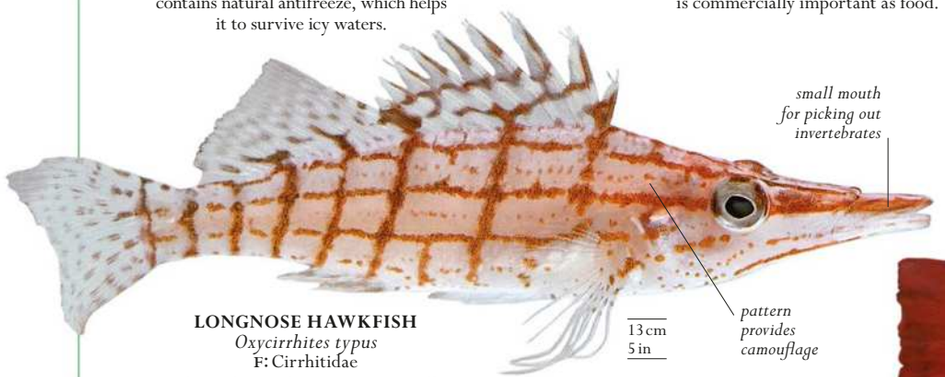
MAORI COD
Paranotothenia magellanica
F: Nototheniidae

Found as far north as New Zealand and Argentina, this Southern Ocean species is commercially important as food.



DOLPHINFISH
Coryphaena hippurus
F: Coryphaenidae

This fast predator of the open ocean can reach a speed of 60 kph (37 mph). It is found worldwide in warm waters.

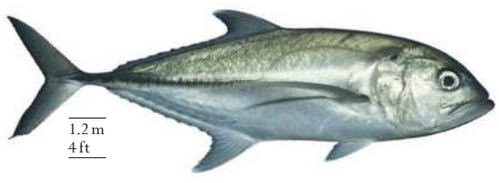


LONGNOSE HAWKFISH
Oxycirrhites typus
F: Cirrhitidae

This Indo-Pacific species stays well camouflaged among sea fans and black corals, where it preys on small invertebrates.

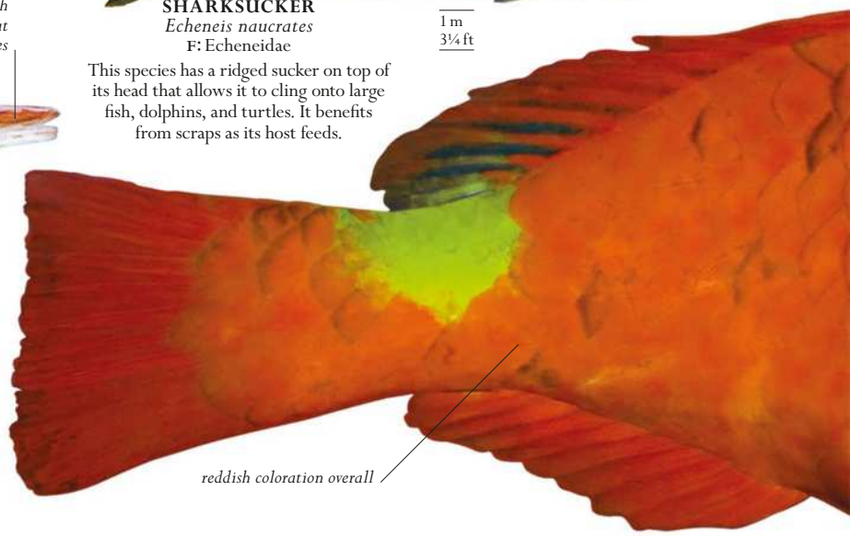
SHARKSUCKER
Echeneis naucrates
F: Echeneidae

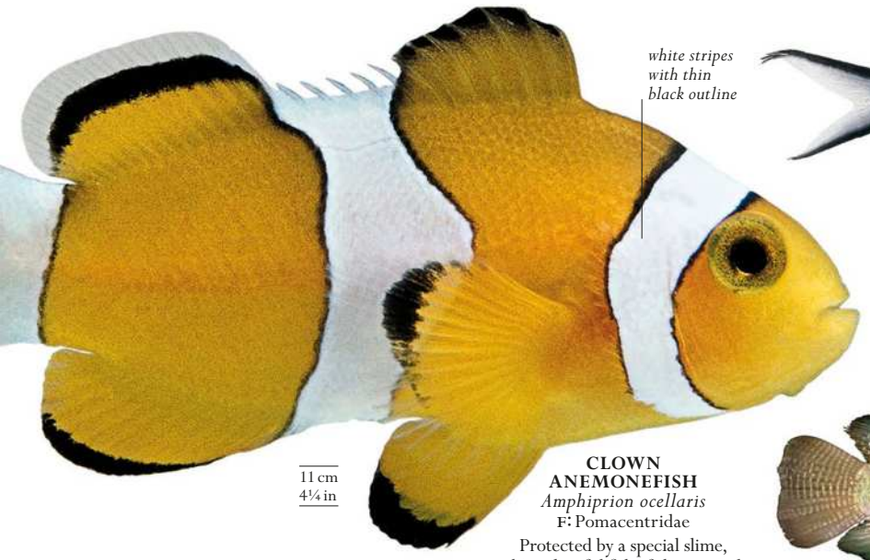
This species has a ridged sucker on top of its head that allows it to cling onto large fish, dolphins, and turtles. It benefits from scraps as its host feeds.



BIGEYE TREVALLY
Caranx sexfasciatus
F: Carangidae

Built for speed, this predator hunts other fish at night over reefs in the Indian and Pacific oceans. Juveniles live inshore and may enter estuaries.

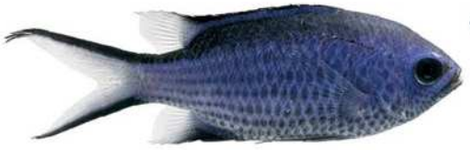




11 cm
4¼ in

CLOWN ANEMONEFISH
Amphiprion ocellaris
F: Pomacentridae

Protected by a special slime, this colourful fish of the tropical W. Pacific finds a safe home among the stinging tentacles of giant sea anemones.



15 cm
6 in

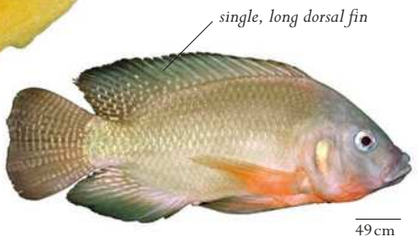
BLUE CHROMIS
Chromis cyanea
F: Pomacentridae

Found in the tropical W. Atlantic, this is one of the most common fish on coral reefs. It lays its eggs using an orange ovipositor tube.

23 cm
9 in

SERGEANT MAJOR
Abudefduf saxatilis
F: Pomacentridae

The most common member of the damselfish family, this brightly striped, small fish can be easily spotted on coral reefs in the Atlantic Ocean.



49 cm
19½ in

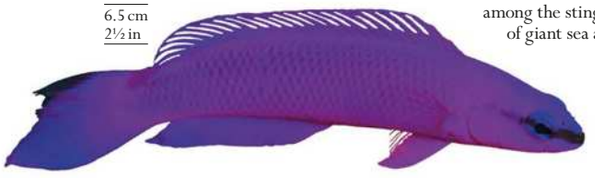
NILE TILAPIA
Oreochromis niloticus
F: Cichlidae

This common species of African lakes is a locally important source of food. The female broods about 2,000 eggs in her mouth.

13 cm
5 in

CHIPOKAE
Melanochromis chipokae
F: Cichlidae

This species is found only around the rocky shores of Lake Malawi in Africa. Other fish in this family are endemic to other lakes.



6.5 cm
2½ in

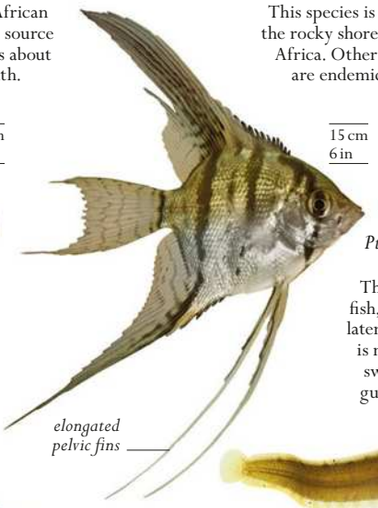
ORCHID DOTTYBACK
Pseudochromis fridmani
F: Pseudochromidae

One of the most brightly coloured species of all coral-reef fish, this Red Sea denizen hides beneath overhangs in steep areas.

10 cm
4 in

CONVICT CICHLID
Amatitlania nigrofasciata
F: Cichlidae

Native to C. American rivers and streams, this cichlid has been introduced elsewhere and is a potential pest competing for food and space.



15 cm
6 in

FRESHWATER ANGELFISH
Pterophyllum scalare
F: Cichlidae

This popular aquarium fish, with its disc-like and laterally compressed body, is native to S. American swamps. Both parents guard the eggs and fry.

75 cm
30 in

COMMON STARGAZER
Kathetostoma laeve
F: Uranoscopidae

Found around southern Australia, the common stargazer buries itself in sand with just its eyes and mouth exposed.

72 cm
28 in

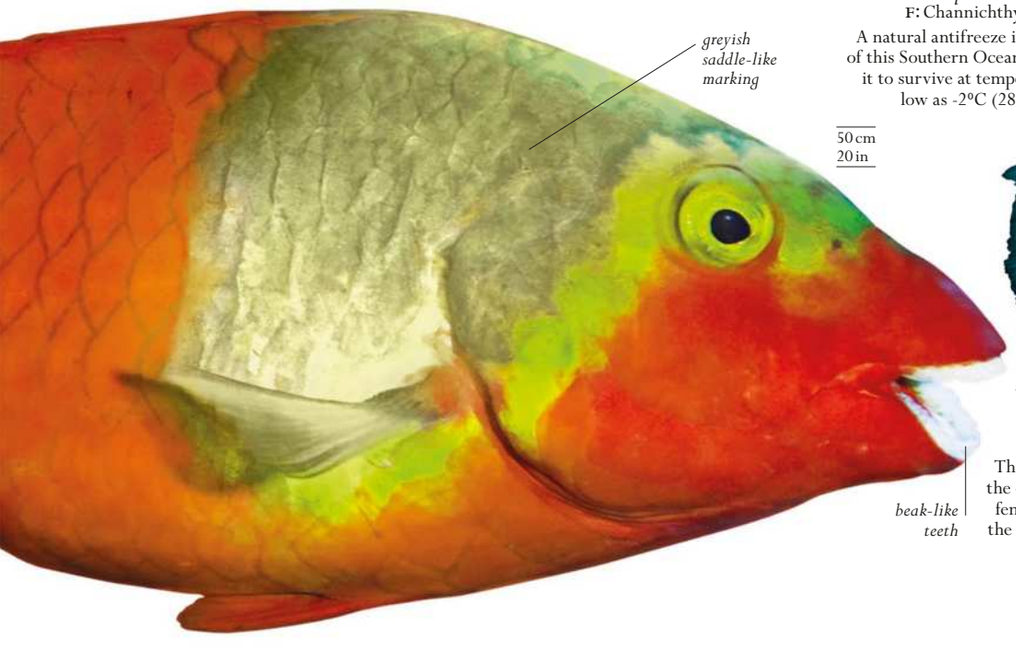
BLACKFIN ICEFISH
Chaenocephalus aceratus
F: Channichthyidae

A natural antifreeze in the blood of this Southern Ocean fish enables it to survive at temperatures as low as -2°C (28.4°F).

25 cm
10 in

GUNNEL
Pholis gunnellus
F: Pholidae

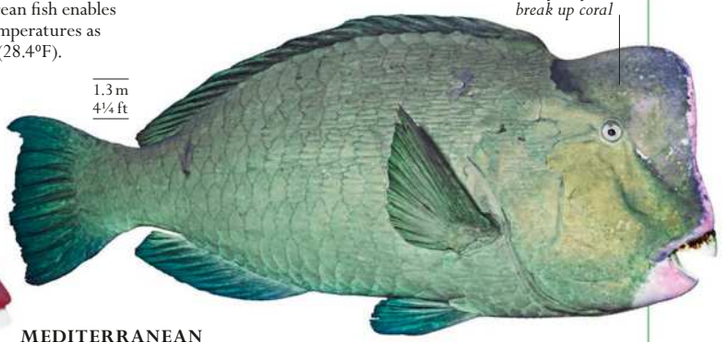
Found in rocky pools in the North Atlantic, this eel-like fish with no scales can be very slippery, sliding away easily from predators.



50 cm
20 in

MEDITERRANEAN PARROTFISH
Sparisoma cretense
F: Scaridae

This Mediterranean species is the only parrotfish in which the female is more colourful than the male. Most other parrotfish species are tropical.



1.3 m
4¼ ft

GREEN HUMPHEAD PARROTFISH
Bolbometopon muricatum
F: Scaridae

A tough beak-like mouth allows this huge Indo-Pacific coral reef resident to crunch up living coral, expelling the remains as sand.

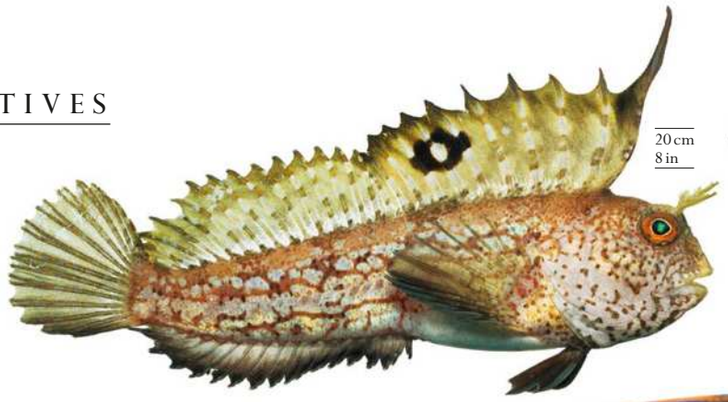
»

» PERCH AND RELATIVES

12 cm
4¾ in

SPOTTED CTENOPOMA
Ctenopoma acutirostre
F: Anabantidae

This tropical freshwater fish is found in the Congo basin of Africa. It often stalks its prey with its head held down.



20 cm
8 in

BUTTERFLY BLENNY
Blennius ocellaris
F: Blenniidae

Like many of its relatives, this fish of the N.E. Atlantic lives on the seabed and guards its eggs, which are often laid in an empty shell.

9 cm
3½ in

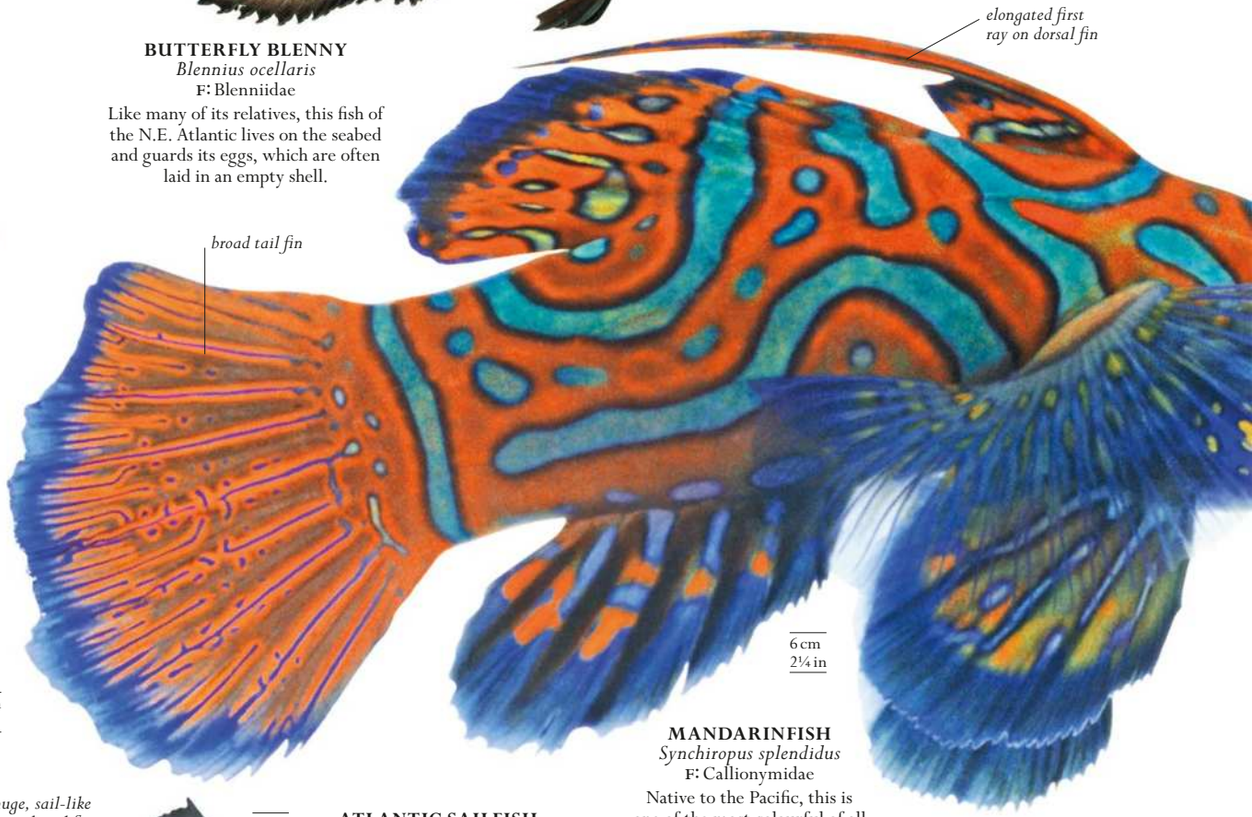
FIREFISH
Nemateleotris magnifica
F: Microdesmidae

Hovering above its coral reef burrow, this fish gathers plankton from the water and darts back into safety if it senses danger.

6.5 cm
2½ in

SIAMESE FIGHTING FISH
Betta splendens
F: Osphronemidae

The original range of this Asian freshwater fish is unclear, but it has been bred for centuries for its fighting ability, particularly strong in males.



6 cm
2¼ in

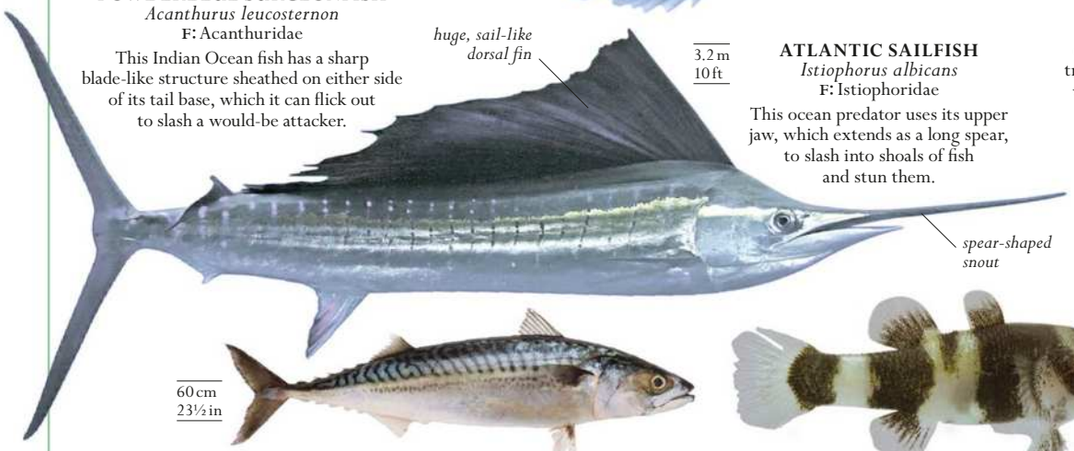
MANDARINFISH
Synchiropus splendidus
F: Callionymidae

Native to the Pacific, this is one of the most colourful of all tropical reef fish. Its vivid colours warn predators of its foul taste.

23 cm
9 in

POWDERBLUE SURGEONFISH
Acanthurus leucosternon
F: Acanthuridae

This Indian Ocean fish has a sharp blade-like structure sheathed on either side of its tail base, which it can flick out to slash a would-be attacker.



3.2 m
10 ft

ATLANTIC SAILFISH
Istiophorus albicans
F: Istiophoridae

This ocean predator uses its upper jaw, which extends as a long spear, to slash into shoals of fish and stun them.

2 m
6½ ft

GREAT BARRACUDA
Sphyraena barracuda
F: Sphyraenidae

Found globally in tropical and subtropical waters, this solitary predator stalks its prey and then accelerates rapidly as it strikes.

60 cm
23½ in

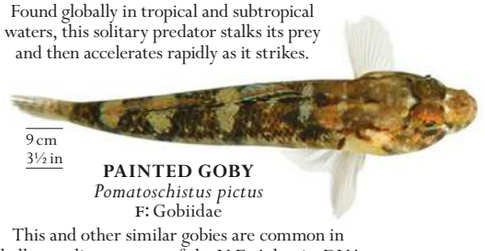
ATLANTIC MACKEREL
Scomber scombrus
F: Scombridae

Living in large shoals in the North Atlantic, this fish feeds voraciously on small fish and plankton. Its streamlined body makes it a fast swimmer.

4 cm
1½ in

BUMBLEBEE FISH
Brachygobius doriae
F: Gobiidae

Found in S.E. Asia, this bottom-dwelling goby is tolerant of brackish water and lives in estuaries and mangroves.



9 cm
3½ in

PAINTED GOBY
Pomatoschistus pictus
F: Gobiidae

This and other similar gobies are common in shallow sediment areas of the N.E. Atlantic. DNA analysis suggests gobies might be placed in a separate order, Gobiiformes.

4.5 m
15 ft

NORTHERN BLUEFIN TUNA
Thunnus thynnus
F: Scombridae

Found globally, this tuna is one of the world's most valuable commercial fish. A fast, dynamic predator, it roams widely, hunting small fish.

25 cm
10 in

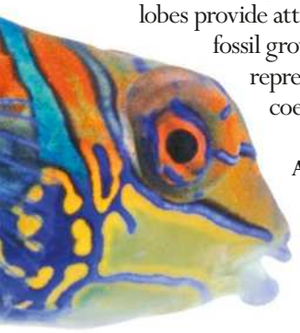
ATLANTIC MUDSKIPPER
Periophthalmus barbarus
F: Gobiidae

As long as it stays moist, this mudskipper can stay out of water for hours by absorbing oxygen through its skin.

LOBE-FINNED FISH

Once considered to be the ancestors of land vertebrates, lobe-finned fish have fins that resemble primitive limbs, with a fleshy base preceding the fin membrane.

Like the ray-finned fish, these are bony fish with a hard skeleton but their fins have a different structure. The fin membrane is supported on a muscular lobe that projects out from the body and is strong enough to let some of these fish shuffle along on their paired pectoral and pelvic fins. Bones and cartilage inside the lobes provide attachment for muscles. There are many fossil groups of lobe-finned fish but living representatives are confined to the marine coelacanths and the freshwater lungfish.



A LIVING FOSSIL

Coelacanths are nocturnal and secretive. The first living specimen was discovered in 1938 – until then only fossil species over 65 million years old were known. The historic find belonged to a species living in deep rocky areas in the western Indian Ocean. A second species was found in Indonesian waters in 1998. They have several unique structural features including an incomplete backbone, residual notochord, and a tail fin with a characteristic extra middle lobe. Their scales are heavy bony plates and they are not long-distance swimmers. Unlike the egg-laying lungfish, coelacanths bear live young as the eggs hatch internally. Gestation may be as long as three years, and this makes their survival precarious if individuals continue to be caught in the nets of deep-sea trawlers.

BREATHING OUT OF WATER

Although most of their fossil ancestors lived in the ocean, modern lungfish are limited to freshwater habitats in South America, Africa, and Australia. All can to some extent breathe air via a connection to the swim bladder – useful when pools dry out seasonally. Some species can survive buried in mud for many months and would die if kept permanently submerged in water, while others still rely mainly on gills for breathing. Their shape and the fact that the larvae of some species have external gills led early zoologists to believe that lungfish were amphibians.

PHYLUM	CHORDATA
CLASSES	COELACANTHI DIPNEUSTI
ORDERS	3
FAMILIES	4
SPECIES	8

DEBATE

FISH ON LAND

While it is generally accepted that land-living vertebrates evolved from a primitive fish or fish-like ancestor in the sea, finding that ancestor is more difficult. Recent work suggests that lungfish are more closely related to tetrapods (four-limbed vertebrates such as mammals) than are coelacanths. In 2002 a fossil lobe-finned fish, *Styloichthys*, was found in China. It appears to show close links between lungfish and tetrapods. The debate continues, but currently coelacanths are not considered direct ancestors of tetrapods.

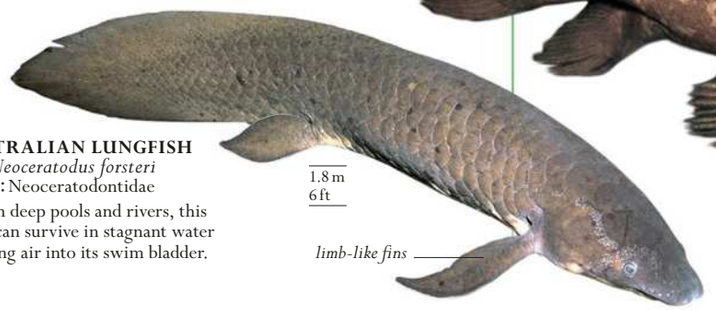
AFRICAN LUNGFISH

All four species of African lungfish have a long body and thread-like pectoral and pelvic fins, collectively called paired fins. The Lepidosireniformes breathe through a pair of lungs derived from their swim bladder.

WEST AFRICAN LUNGFISH
Protopterus annectens
F: Protopteridae
When the lakes in which it lives dry out, this lungfish survives by burying itself in mud, forming a cocoon with an inlet for air.

AUSTRALIAN LUNGFISH

The single species in the order Ceratodontiformes has a long body, large scales, paddle-like paired fins, and a tapering tail. It can breathe through its lungs for short periods, but cannot survive if its habitat dries out.

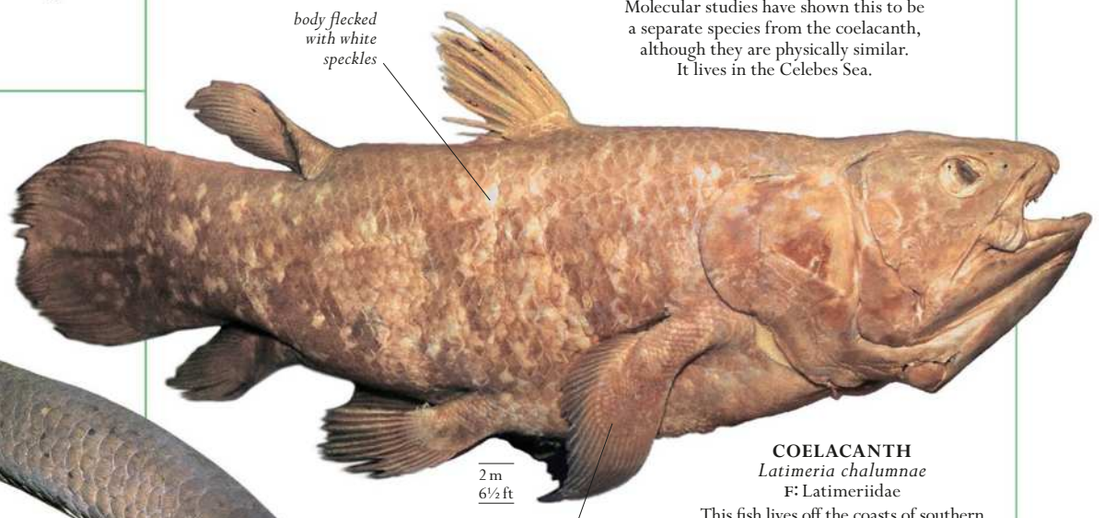


AUSTRALIAN LUNGFISH
Neoceratodus forsteri
F: Neoceratodontidae
Living in deep pools and rivers, this lungfish can survive in stagnant water by gulping air into its swim bladder.

COELACANTHS

The two primitive fish from the order Coelacanthiformes have limb-like fleshy bases to their pectoral and pelvic fins, and large bony scales. In life, these fish are a metallic blue with pale spots, but the colour fades on death. Interesting 'head-standing' behaviour has been observed from a submersible.

INDONESIAN COELACANTH
Latimeria menadoensis
F: Latimeriidae
Molecular studies have shown this to be a separate species from the coelacanth, although they are physically similar. It lives in the Celebes Sea.



COELACANTH
Latimeria chalumnae
F: Latimeriidae
This fish lives off the coasts of southern Africa and Madagascar in steep, rocky, underwater terrain and hides in deep ocean caves during the day.

AMPHIBIANS

Amphibians are cold-blooded vertebrates that thrive in freshwater habitats. Some spend their whole lives in water; others only require water to breed. On land, they must find damp places as their skin is permeable and does not protect them from drying out.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDERS	3
FAMILIES	74
SPECIES	8,212

Large numbers of male and female Costa Rican golden toads gather in a pool to mate. The species is now extinct.

A female of the North American Jefferson's salamander attaches a mass of eggs to a submerged twig in early spring.

When the eggs hatch, the male red-backed poison frog carries the tadpoles to bromeliad pools in the canopy.

DEBATE

OUR BIGGEST CHALLENGE?

A third of the world's amphibians face extinction in the near future and this poses a huge conservation challenge. This danger of extinction is largely due to the destruction and pollution of freshwater habitats, but amphibians are also threatened by the global spread of the disease chytridiomycosis, caused by a fungus that invades their soft skin.

The three orders of living amphibians are thought to share a common ancestor, but their origins are still uncertain. There is an enormous gap in the fossil record between the first land animals to evolve from fish – the tetrapods, some 375 million years ago – and a frog-like creature that lived 230 million years ago.

Amphibians have a unique and complex life cycle and occupy very different ecological niches at different stages of their lives. For most amphibians, their eggs hatch into larvae – called tadpoles in frogs and toads – that live in water, often in very high densities, and feed mostly on algae and other plant material. As larvae, they grow rapidly and then undergo a complete change of form – metamorphosis – to become land-living adults. As adults, all amphibians are carnivores, most feeding on insects and other small invertebrates. They typically lead secretive and solitary lives, except when they return to ponds and streams to breed. Most amphibians thus require two very different habitats during their lives: water and land. During metamorphosis, they undergo a wide variety of anatomical and physiological changes – from aquatic creatures that swim with a tail and breathe through gills, to terrestrial animals that move with four limbs and breathe through lungs.

DIVERSE PARENTAL CARE

Some amphibians produce huge numbers of eggs that are left to fend for themselves, so that only a very few will survive. Many others have evolved various forms of parental care. This is generally associated with the production of far fewer offspring, so that reproductive success is achieved by caring for a manageable number of young, rather than by producing as many eggs as possible. Parental care takes many forms, including defending eggs or larvae against predators, feeding tadpoles with unfertilized eggs, and carrying tadpoles from one place to another. In some species, such as the midwife toads and some poison frogs, parental care is the duty of the father. In many salamanders and caecilians, the mother is the sole protector of the young. In a few frog species, mother and father establish a durable pair bond and share parental duties.

READY TO HATCH >
Tadpoles of the Tanzanian Mitchell's reed frog wriggle within their egg membranes, just prior to hatching.

AMPHIBIAN GROUPS

The three orders have very different body forms: the tailless frogs and toads, the caecilians, which resemble earthworms, and the lizard-like salamanders and newts.

FROGS AND TOADS
» 356

CAECILIANS
» 369

SALAMANDERS AND NEWTS
» 370

FROGS AND TOADS

With powerful hind limbs tucked under its body, a wide mouth, and protruding eyes, the typical frog has a unique and unmistakable body shape.

Anura, the name of the order of frogs and toads, means "animals without a tail". As adults, all other amphibians have a tail, but in the anurans, the tail gradually disappears during metamorphosis from the larval to the adult stage of the life cycle. The larvae, known as tadpoles, feed chiefly on plant material and have a spherical body that contains the long, coiled gut required by such a diet. The adults, in contrast, are totally carnivorous, feeding on a wide range of insects and other invertebrates, with larger species also taking small reptiles and mammals, as well as other frogs.

INGENIOUS ADAPTATIONS

Frogs and toads catch their prey by ambush, most spectacularly by jumping. In many frogs and toads, the hind limbs are modified for jumping, being much longer than the forelimbs and very muscular. Jumping is also an effective method of escaping from predators, of which frogs and toads have many.

Not all anurans jump, however. Many have hind limbs adapted for other kinds of locomotion, including swimming, burrowing, climbing, and, in a few species, gliding through the air. Most frogs and toads live in damp habitats, close to the pools and streams in which they breed, but there are several species adapted to life in very arid areas. The greatest diversity of anurans is found in the tropics, particularly in rainforests. Many are active by day, while others are nocturnal. Some species are cleverly camouflaged; in contrast, others are brightly coloured, advertising that they are poisonous or unpleasant to taste.

COURTSHIP AND BREEDING

Anurans differ from other amphibians in having a voice and very good hearing. Males of most species call to attract females, making sounds characteristic of their species. In all but a very few species, fertilization is external, the male shedding sperm onto the eggs as they emerge from the female's body. To do this, the male clasps the female from above – a position known as amplexus. The duration of amplexus varies between species – from a few minutes to several days.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	ANURA
FAMILIES	54
SPECIES	7,244

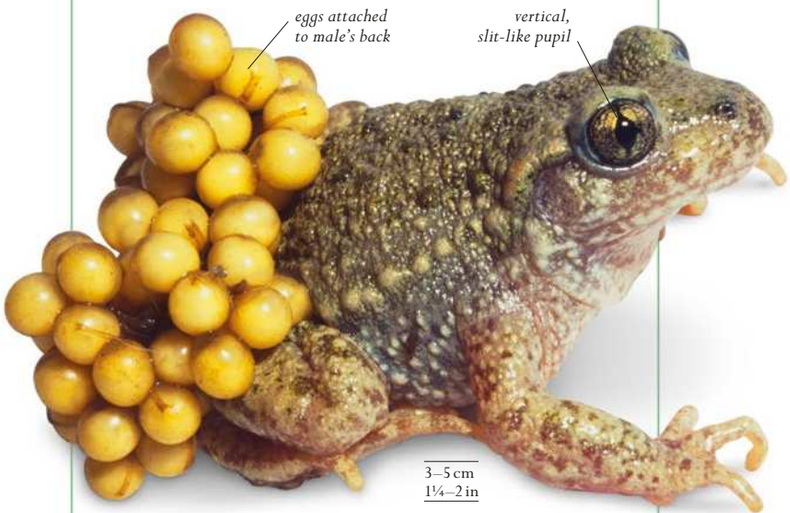
DEBATE

FROG OR TOAD

The distinction between frogs and "toads" is biologically meaningless and the two words are used differently in different parts of the world. In Europe and North America, for example, the term "toad" refers to species in the family Bufonidae, but this also includes the South and Central American harlequin frogs. In general, toads have rough skins, are slow-moving, and often burrow in the ground, whereas frogs are smooth-skinned, agile, and fast-moving, and spend much of their time in water. A group of smooth-skinned, aquatic frogs native to Africa were once known as clawed toads, but are now called clawed frogs.

ALYTIDAE

Males of the Alytidae, a small family of terrestrial frogs, call at night to attract females. When mating, the male midwife toad attaches fertilized eggs to his back. He carries them until they are ready to hatch, when he releases the tadpoles into water. Occasionally, a male may carry egg strings from more than one female. With painted frogs, a female mates with several males, producing up to 1,000 eggs, which are dropped into water.



COMMON MIDWIFE TOAD
Alytes obstetricans
Found in W. and C. Europe, this midwife toad has a plump body and powerful forelimbs adapted for digging. It hides in a burrow by day.

SQUEAKERS AND RELATIVES

The Arthroleptidae are a large, diverse family of frogs occurring across sub-Saharan Africa – in forest, woodland, and grassland, some at high altitudes. Its members range from tiny "squeakers", named for their high-pitched call, to large treefrogs.

WEST AFRICAN SCREECHING FROG
Arthroleptis poecilonotus
The female of this small species lays large eggs in soil cavities. The male is noted for his loud call.

RIO BENITO LONG-FINGERED FROG
Cardioglossa gracilis
An inhabitant of lowland forest, this frog breeds in streams. Males call from nearby slopes.

WEST CAMEROON FOREST TREEFROG
Leptopelis nordequatorialis
This large treefrog lives in montane grasslands of W. Africa. Males call to females near water when breeding, and eggs are deposited in ponds or marshes.

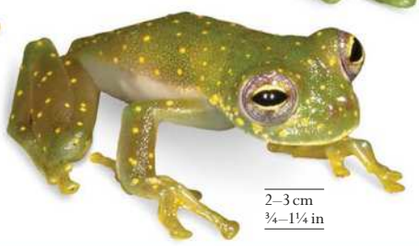
AFRICAN TREEFROG
Leptopelis modestus
This species is found near streams in forests of W. and C. Africa. Females are larger than males.

GLASS FROGS

Found in Central and South America, frogs of the family Centrolenidae are known as "glass frogs" because many species have transparent skin on the underside through which their internal organs are visible.

LIMON GIANT GLASS FROG
Sachatamia ilex
This arboreal frog lives in wet vegetation near streams. It has dark green bones, visible through its skin.

FLEISCHMANN'S GLASS FROG
Hyalinobatrachium fleischmanni
Males of this species are territorial, using calls to defend their territory and to attract females. The females lay eggs on leaves over water.

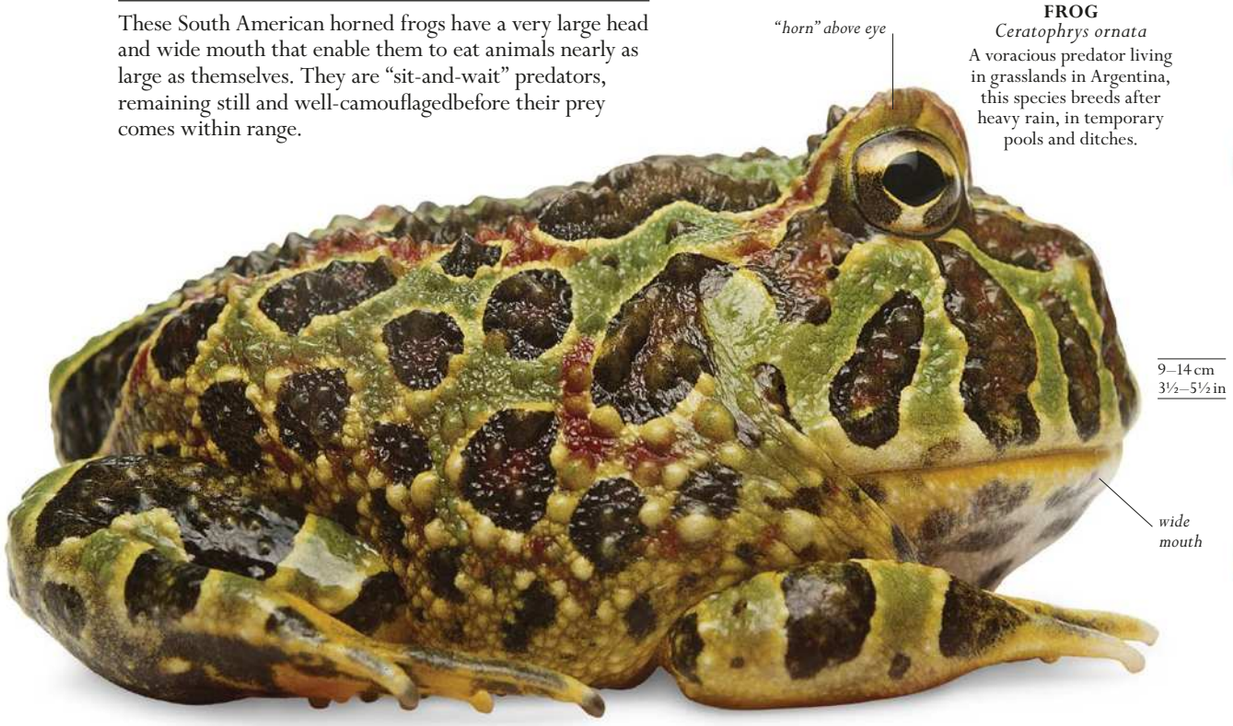


WHITE-SPOTTED COCHRAN FROG
Sachatamia albomaculata
This species is found in wet lowland forests, and breeds near streams. Males call to females from low vegetation nearby.

EMERALD GLASS FROG
Espadarana prosoblepon
Males of this arboreal frog are fiercely territorial, defending their space by calling, and occasionally fighting rivals while hanging upside down.

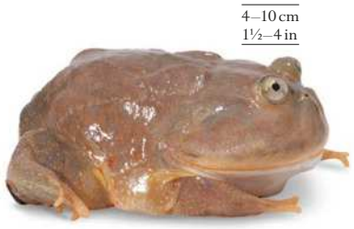
CERATOPHRYIDAE

These South American horned frogs have a very large head and wide mouth that enable them to eat animals nearly as large as themselves. They are "sit-and-wait" predators, remaining still and well-camouflagedbefore their prey comes within range.



ORNATE HORNED FROG
Ceratophrys ornata
A voracious predator living in grasslands in Argentina, this species breeds after heavy rain, in temporary pools and ditches.

CRANWELL'S HORNED FROG
Ceratophrys cranwelli
Spending much of its life underground, this large frog emerges after heavy rain to mate and lay its eggs in pools.



BUDGETT'S FROG
Lepidobatrachus laevis
This frog has a flattened body, a wide mouth, and fangs. It spends dry periods in a cocoon below ground, emerging to breed after rain.

ROBBER FROGS

Found in North, Central, and South America, the Craugastoridae produce eggs that develop directly into small adults, without a tadpole stage. Eggs may be deposited on the ground or in vegetation. Many species show parental care of the eggs.

BROAD-HEADED RAIN FROG
Craugastor megacephalus
This C. American frog hides in a burrow by day and emerges at night. It lays its eggs in leaf litter.

ISLA BONITA ROBBER FROG
Craugastor crassidigitus
Native to the humid forests of C. America, this ground-living frog is also found in coffee plantations and pasture.

COMMON RAIN FROG
Craugastor fitzingeri
In this forest species, the male calls to the larger female from an elevated perch. Eggs are laid in the ground and are guarded by the female.

TRUE TOADS

Distributed worldwide, the family Bufonidae is large and diverse. Its members are characterized by shortened forelimbs, hind limbs that are used for walking or hopping, dry warty skin, and parotoid glands behind the eyes. However, this family also includes the more slender and long-limbed South and Central American harlequin frogs and the stubfoot toads.

horizontal pupil

green blotches on back

warty skin

9–12 cm
3½–4¾ in

COMMON AFRICAN TOAD
Sclerophorus regularis
Common in the whole of Africa except the driest parts of Sahara and Namib deserts, this thickset toad breeds in dams and ponds. Males produce rasping, duck-like calls to attract females.

5–11.5 cm
2–4½ in

5–10 cm
2–4 in

MALAYAN TREE TOAD
Rentapia hosii
Found in E. Asia, this toad is unusual in living a largely arboreal life. It has adhesive pads on its toes that enable it to climb trees.

GREEN TOAD
Bufotes viridis
A native of sandy habitats, this colourful toad is found in Europe and W. Asia. It emerges from its burrow in spring to breed in ponds.

5–10 cm
2–4 in

NATTERJACK
Epidalea calamita
Compared with other true toads, this species has short legs and runs like a mouse. Occurring across Europe, it breeds from spring to summer.

CERATOBATRACHIDAE

Found in Southeast Asia, China, and several Pacific islands, frogs of this family produce large eggs that hatch directly into small frogs. In many species, the tips of the fingers and toes are enlarged.

FIJI GROUND FROG
Cornufer vitianus
The populations of this species on several of the Fijian Islands have been wiped out following the introduction of mongooses.

2.5–11 cm
1–4¼ in

horn-like projection above eye

flat, triangular head

5–8 cm
2–3¼ in

SOLOMON ISLANDS HORNED FROG
Cornufer guentheri
This species has a pointed snout and horn-like projections above its eyes. It hides among dead leaves.

BOMBINATORIDAE

These small aquatic toads are found in Europe and Asia. They have a flattened body and many are brightly coloured. Fire-bellied toads are active by day, but the dull-coloured barbourulas from the Philippines and Borneo are nocturnal.

prominent eyes

bright red underside

bright green coloration

3–5 cm
1¼–2 in

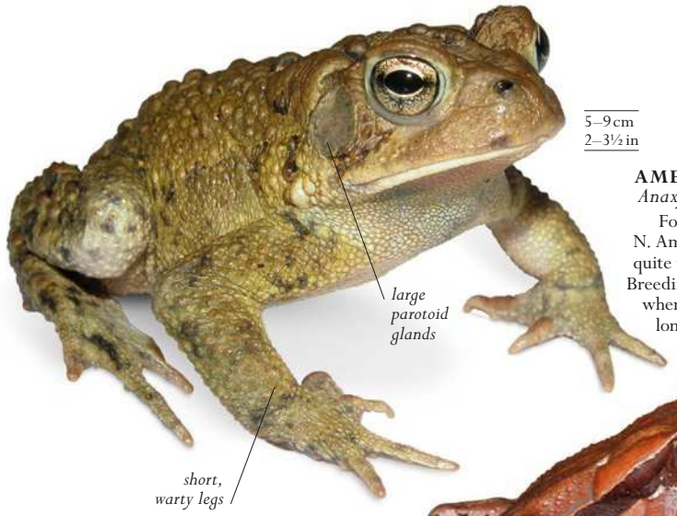
ORIENTAL FIRE-BELLIED TOAD
Bombina orientalis
Found in China and Korea, this small, squat frog can produce a toxic skin secretion. If attacked, it displays its bright belly colours.

RAIN FROGS

Members of the family Brevicipitidae are found in eastern and southern Africa. During mating, the much smaller male is glued onto a female's back by a special skin secretion.

3–5 cm
1¼–2 in

DESERT RAIN FROG
Breviceps macrops
Living away from standing water, this burrowing frog lives and breeds among Namibian sand dunes, occasionally moistened by sea fog.



5–9 cm
2–3½ in

AMERICAN TOAD
Anaxyrus americanus
Found in eastern N. America, this toad is quite variable in colour. Breeding occurs in ponds where males produce long trilling calls.

4–8 cm
1½–3¼ in

TRUANDO TOAD
Rhaebo haematiticus
Living among leaf litter in forests of C. and S. America, this broad-headed toad lays its eggs in long strings in rocky pools.

8–20 cm
3¼–8 in

EUROPEAN COMMON TOAD
Bufo bufo
Found throughout Europe and N. Africa, this species breeds in spring, with males outnumbering the much larger females by about three to one.

5.5–9.5 cm
2¼–3¾ in

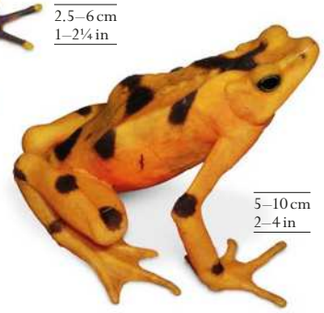
GREEN CLIMBING FROG
Incilius coniferus
Native to C. and S. America, this nocturnal toad is often found climbing among vegetation.

VARIABLE HARLEQUIN FROG
Atelopus varius
This aggressive species from Panama and Costa Rica has vivid and variable coloration. It lives near streams and is active during the day.

2.5–6 cm
1–2¼ in

2.5–4 cm
1–1½ in

GUYANAN STUBFOOT TOAD
Atelopus barbotini
This small toad from Guyana has a flattened body. It breeds throughout the year in forest streams.



5–10 cm
2–4 in

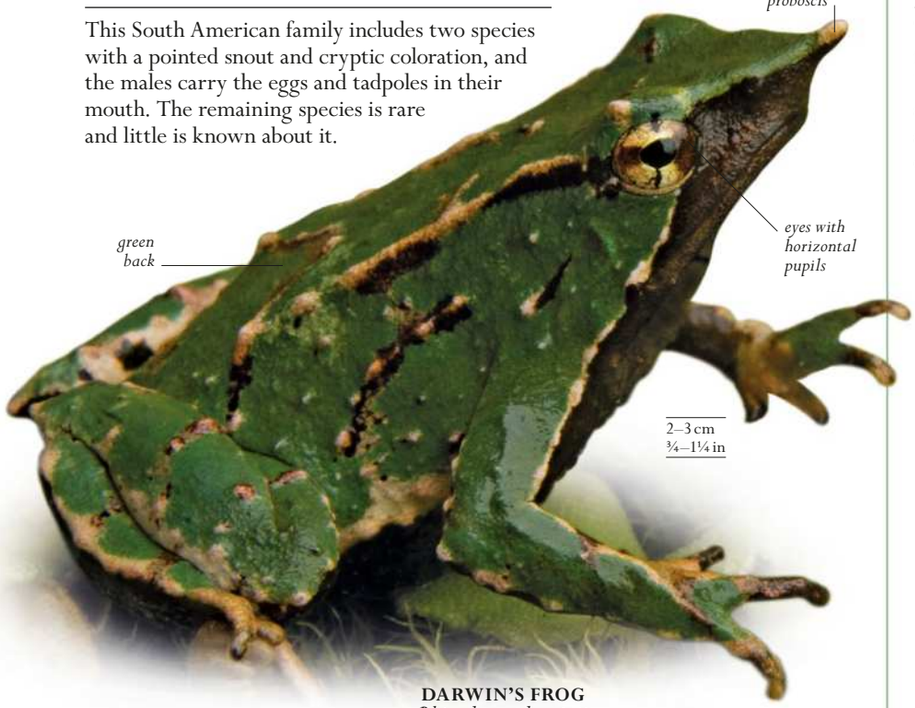
PANAMANIAN GOLDEN FROG
Atelopus zeteki
This brightly coloured frog from Panama breeds in pools after heavy rain. It may now be extinct in the wild.

10–24 cm
4–9½ in

CANE TOAD
Rhinella marina
One of the world's largest toads, this American species was introduced in Australia, where it is now a serious threat to native wildlife.

RHINODERMATIDAE

This South American family includes two species with a pointed snout and cryptic coloration, and the males carry the eggs and tadpoles in their mouth. The remaining species is rare and little is known about it.

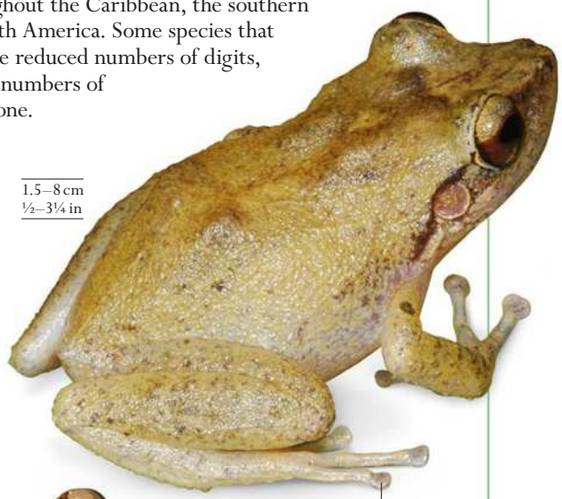


2–3 cm
¾–1¼ in

DARWIN'S FROG
Rhinoderma darwinii
Found in Chile and Argentina, this frog has a unique form of parental care – the young develop from egg to froglet in their father's vocal sacs.

ELEUTHERODACTYLIDAE

This group of frogs, whose eggs develop directly into froglets, is found throughout the Caribbean, the southern USA, and northern South America. Some species that are extremely small have reduced numbers of digits, and produce very small numbers of eggs – sometimes only one.



1.5–8 cm
½–3¼ in

PUERTO RICAN COQUI
Eleutherodactylus coqui
Native to Puerto Rico, this frog gets its name from its two-part call – the "co" is a warning to other males and the "qui" attracts females.

1.5–2.5 cm
½–1 in

large toe pads

CARETTA ROBBER FROG
Diasporus diastema
This small and very agile frog is arboreal and active at night. It lays its eggs in water-filled cavities in bromeliads growing epiphytically in trees.

CANE TOAD
Rhinella marina

One of the largest toads in the world, the cane toad is a hardy creature with a huge appetite. Also known as the marine toad, it is mainly a resident of dry environments, scrub, and savanna. It commonly lives around human settlements and is often seen under streetlights, waiting for insects to fall. The female is larger than the male, and the largest females can lay more than 20,000 eggs in a single clutch. Males attract females with a slow, low-pitched trill. They have few enemies, as at all stages of their life cycle they are distasteful or toxic to potential predators. In Australia they have become a major pest – they are poisonous to native and domestic animals, injurious to humans, and breed so prolifically as to be out of control.

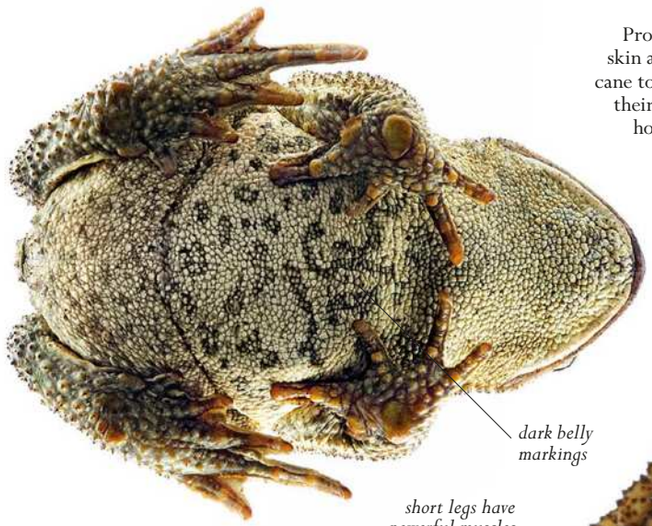
SIZE 10–24 cm (4–9½ in)
HABITAT Non-forested habitats
DISTRIBUTION C. and S. America; introduced to Australia and elsewhere
DIET Terrestrial invertebrates

parotoid gland

adult coloration is yellow, olive, or reddish brown

warts on male's skin develop dark, sharp spines in the breeding season

NIGHT HUNTER >
Protected by their poisonous skin and unafraid of predators, cane toads emerge at night from their daytime hiding places to hop about in search of prey.



dark belly markings

^ PALE BELLY
The cane toad's belly and throat are relatively smooth, and mostly pale in colour. Toads have permeable skin and must hide by day to conserve water.

short legs have powerful muscles for jumping

DEBATE

PEST CONTROL

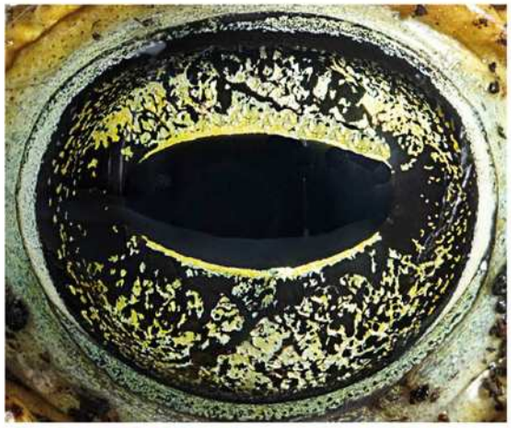
The cane toad gets its name from Australia, where it was introduced into Queensland in 1935 to control insect pests on sugar cane farms. The toads flourished in Australia, feasting on native fauna and building up much denser populations than in their native habitat. Still spreading at an alarming rate, they now occur throughout eastern and northern Australia, and are likely to migrate further. Scientists are working on methods to limit their numbers and contain their territorial expansion.

nostril

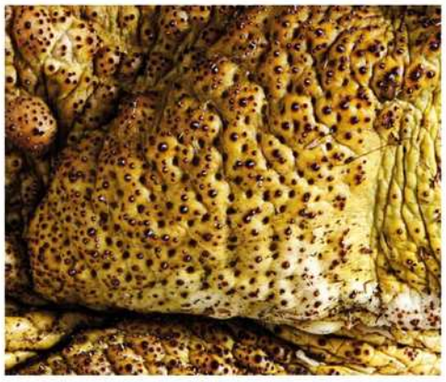
wide mouth used to take prey of any size that will fit inside it

male's throat is distended when he produces his loud, trill-like mating call

∨ IRIDESCENT IRIS
Like most toads, cane toads have large, protruding eyes. They have very good eyesight, enabling them to detect small, moving objects and to lunge accurately at their insect prey.



GLAND >
The enormous parotoid glands – located on each side of the head – secrete a powerful toxin that is distasteful to some predators and lethal to most.

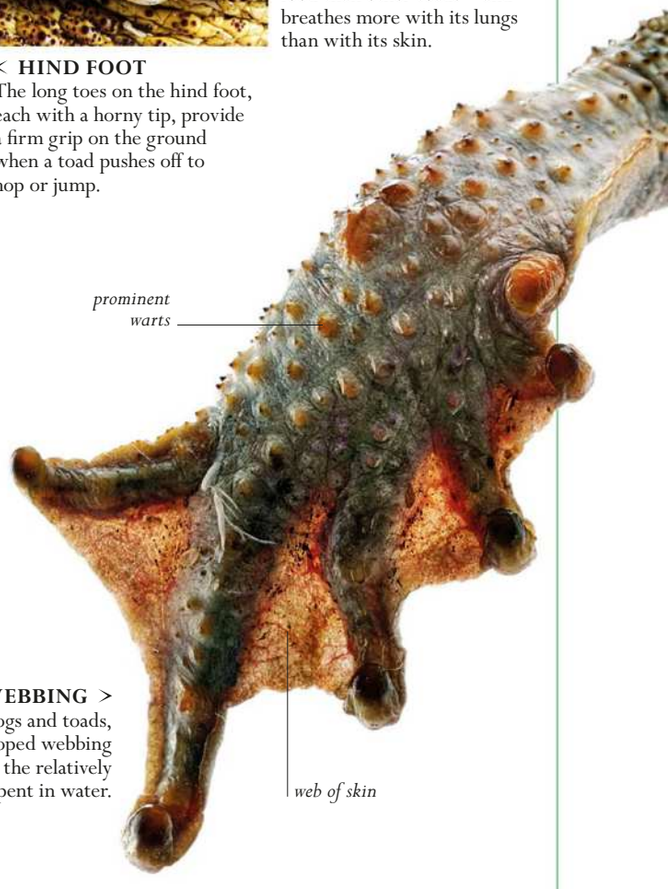


∧ NOSTRIL
The cane toad relies more on its sense of smell to find food than other toads – and breathes more with its lungs than with its skin.

EAR >
Toads rely on their hearing to identify potential enemies. At night, it is especially important for females, who locate males by their calls.

FRONT FOOT ∧
In the breeding season, males develop dark, horny nuptial pads on their first three fingers. These enable them to clasp females firmly during mating.

< HIND FOOT
The long toes on the hind foot, each with a horny tip, provide a firm grip on the ground when a toad pushes off to hop or jump.



prominent warts

web of skin

WEBBING >
Compared with many other frogs and toads, cane toads have poorly developed webbing between their toes. This reflects the relatively small part of their lives spent in water.

POISON-DART FROGS

Called poison or poison-dart frogs, the Dendrobatidae are noted for their bright coloration. This warns predators that the skin of these frogs contains powerful toxins, which are derived from their insect prey. These frogs are found in the forests of Central and South America. They are active by day.

MIMIC POISON FROG
Ranitomeya imitator
Found in Peru, this frog is variable in colour and is similar in appearance to at least three other frog species.

DORIS SWANSON'S POISON-DART FROG
Andinobates dorisswansonae
Discovered in 2006, this species is found only in a fragment of forest in the Colombian Andes. It lives on the forest floor and on low-growing bromeliads.

SPOTTED-THIGHED POISON-DART FROG
Allobates femoralis
The male of this S. American species guards the eggs laid by the female in leaf nests. Later, he carries the tadpoles to water on his back.

LOVELY POISON-DART FROG
Phyllobates lugubris
This poisonous frog is found in leaf litter of lowland forests from Nicaragua to Panama. The male cares for the eggs and tadpoles.

GOLDEN POISON FROG
Phyllobates terribilis
Possibly the most toxic of all poison-dart frogs, this terrestrial species occurs in lowland forests of Colombia.

RAINFOREST ROCKET FROG
Silverstoneia flotator
This frog is found in Costa Rica and Panama. Its tadpoles have an upward-tilting mouth, which helps them feed from the water surface.

THREE-STRIPED POISON FROG
Ameerega trivittata
This S. American frog calls by day, especially after rain. It lays its eggs in leaf litter and is common near human settlements.

MARSUPIAL FROGS

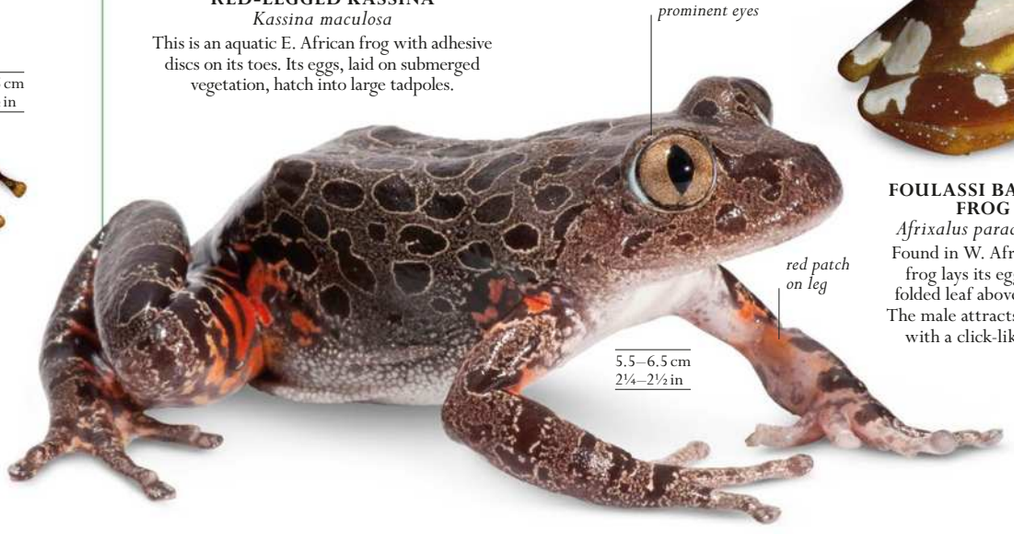
Found in South and Central America, the Hemiphractidae carry their eggs on their back, where they hatch directly into froglets. Some also carry the eggs in a pouch, hence the name "marsupial frogs".

SUMACO HORNED TREEFROG
Hemiphractus proboscideus
This species is found in Colombia, Ecuador, and Peru. The female carries her eggs on her back, but does not have a pouch.

REED AND SEDGE FROGS

Also called African treefrogs, this large family, the Hyperoliidae, includes many agile climbers that gather in trees, bushes, or reeds near water to find mates and lay eggs. Some of the species are brightly coloured, with marked differences between the sexes.

RED-LEGGED KASSINA
Kassina maculosa
This is an aquatic E. African frog with adhesive discs on its toes. Its eggs, laid on submerged vegetation, hatch into large tadpoles.



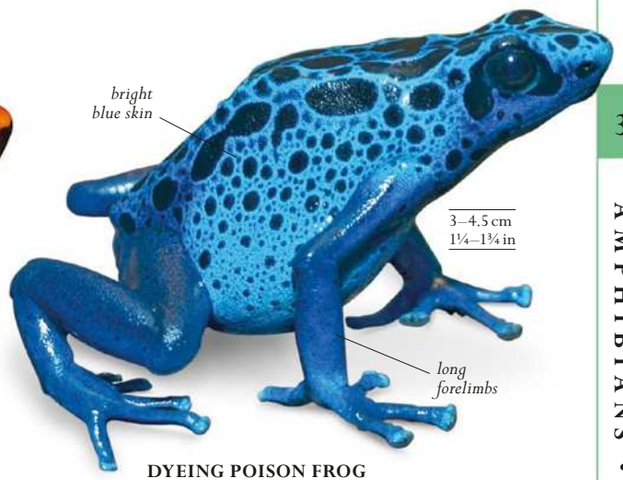
FOULASSI BANANA FROG
Afrixalus paradorsalis
Found in W. Africa, this frog lays its eggs in a folded leaf above water. The male attracts females with a click-like call.

GREEN POISON-DART FROG
Dendrobates auratus
The males of this species fight to secure a territory. The male defends the eggs and, when they hatch, carries tadpoles to small pools in bromeliads.

2.5–6 cm
1–2¼ in

3–4 cm
1¼–1½ in

YELLOW-BANDED POISON-DART FROG
Dendrobates leucomelas
Found in wet forests of northern S. America, this frog derives its skin toxin from the ants on which it feeds.



3–4.5 cm
1¼–1¾ in

DYEING POISON FROG
Dendrobates tinctorius
This is the blue, or *azureus*, form of this variable S. American species. Both sexes protect the eggs and are very aggressive while defending their territory.

2–2.5 cm
¾–1 in

STRAWBERRY POISON-DART FROG
Oophaga pumilio
The female of this species cares for the young by carrying tadpoles to water-filled bromeliads and feeding them with unfertilized eggs.

3–4 cm
1¼–1½ in

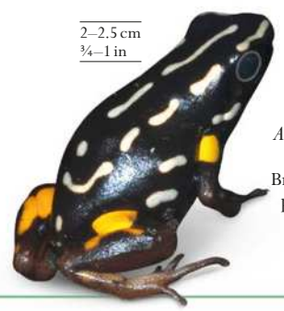
SPLASHBACK POISON FROG
Adelphobates galactonotus
Living in leaf litter in Brazilian forests, this frog lays eggs on the ground and carries the tadpoles to water.

1.5–2 cm
½–¾ in

RIO MADEIRA POISON FROG
Adelphobates quinquevittatus
Found in Brazil and Peru, this tiny frog carries its tadpoles to water-filled holes, where the female feeds them with unfertilized eggs.

2 cm
¾ in

GRANULAR POISON FROG
Oophaga granulifera
This species is found in Costa Rica and Panama. Females care for the young by feeding them with unfertilized eggs.



2–2.5 cm
¾–1 in

BRAZIL-NUT POISON FROG
Adelphobates castaneoticus
This species is found in Brazil. The males of this frog place tadpoles individually into small, water-filled tree-holes. The tadpoles are voracious feeders.

3–4.5 cm
1¼–1¾ in

TINKER REED FROG
Hyperolius tuberilinguis
This agile frog is noted for its loud call. In the mating season, thousands of males may gather around a pond to produce a deafening chorus.

2–3.5 cm
¾–1½ in

BOLIFAMBA REED FROG
Hyperolius bolifambae
This small W. African frog occurs in bushland, and breeds in pools. The male's call is a high-pitched buzz.

AUSTRALIAN GROUND FROGS

The Limnodynastidae, found in Australia and New Guinea, include many terrestrial and burrowing frog species. Two recently extinct species uniquely brooded their eggs in the stomach.

3–6 cm
1¼–2¼ in

BROWN-STRIPED MARSH FROG
Limnodynastes peronii
This Australian frog survives dry periods by burying itself in the ground. It emerges to breed after heavy rain, and deposits its eggs in floating foam nests.

TREEFROGS

The Hylidae are a large family widespread worldwide. They are especially well represented in the New World. These frogs have long, slender limbs and adhesive discs on their fingers and toes. Most are arboreal and nocturnal. Many gather to breed in noisy choruses.

SPLENDID LEAF FROG
Cruziohyla calcarifer
This frog occurs in C. and northern S. America and lives high up in trees. It glides from one tree to another, using its extended webbed feet as parachutes.

RUFOUS-EYED STREAM FROG
Duellmanohyla rufioculis
Found in forests of Costa Rica, this frog breeds in fast-flowing streams. Its tadpoles have a modified mouth with which they attach themselves to rocks.

SPRING PEEPER
Pseudacris crucifer
Found in moist woodland in the E. USA and Canada, the spring peeper's distinctive high-pitched call indicates that spring is underway.

PARADOXICAL FROG
Pseudis paradoxa
This aquatic frog is so named because its tadpoles are four times longer than the adult. It is found in S. America and Trinidad.

AMAZON MILK FROG
Trachycephalus resinifictrix
Living high in the canopy of S. American forests, this frog deposits its eggs in water-filled tree-holes, where the tadpoles then develop into froglets.

ROSENBERG'S GLADIATOR FROG
Boana rosenbergi
Males of this C. and S. American frog dig pools in damp ground in which the eggs are laid. They defend them against rivals in fights that can be fatal.

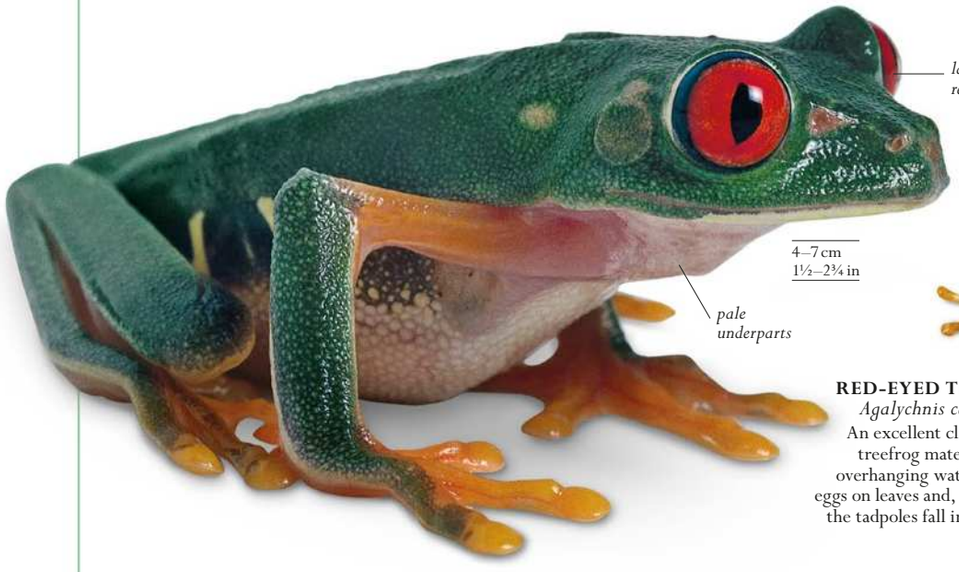
ORANGE-LEGGED LEAF FROG
Phyllomedusa hypochondrialis
A native of dry habitats in northern S. America, this climbing frog reduces water loss by rubbing a waxy secretion over its skin.

FRINGE-LIMBED TREEFROG
Ecnomiohyla miliaria
This large C. American treefrog has fringes of skin on the limbs that may enable it to glide from one tree to another.

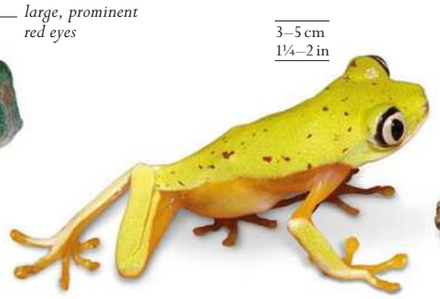
BOULENGER'S SNOUTED TREEFROG
Scinax boulengeri
Found in C. America and Colombia, this frog breeds in temporary pools created after rain. Males return night after night to the same calling perch to attract mates.

CUBAN TREEFROG
Osteopilus septentrionalis
Native to Cuba, the Cayman Islands, and the Bahamas, this treefrog has been introduced to Florida, where it preys on native frogs, reducing their population.

COMMON TREEFROG
Hyla arborea
Males of this European treefrog gather in spring, calling in loud choruses to attract females. Mating pairs descend to lay eggs in nearby ponds.



RED-EYED TREEFROG
Agalychnis callidryas
An excellent climber, this treefrog mates in trees overhanging water. It lays its eggs on leaves and, upon hatching, the tadpoles fall into the water.



LEMUR FROG
Agalychnis lemur
This C. American treefrog is nocturnal, sleeping on the underside of leaves during the day. It lays its eggs on leaves over water.

GIANT BROAD-HEADED TREEFROG
Osteocephalus taurinus
This arboreal frog lives in S. American forests. It mates after rain, and lays its eggs on the surface of pools.

SMALL-HEADED TREEFROG
Dendropsophus microcephalus
Found in C. and S. America and Trinidad, this frog breeds in pools. It is pale yellow by day, and red-brown by night.

2–3 cm
¾–1¼ in

NEW ZEALAND FROGS

This family, the Leiopelmatidae, is composed of four species of frogs that are all confined to New Zealand. They are characterized by extra vertebrae and, unlike most frogs, they kick their legs alternately when swimming. They live in humid forests and are nocturnal.

2.5–3.5 cm
1–1½ in

COROMANDEL NEW ZEALAND FROG
Leiopelma archeyi
Found only in New Zealand's North Island, this terrestrial frog lays its eggs under logs. It is critically endangered, as a result of habitat loss and disease.

TROPICAL GRASS FROGS

The Leptodactylidae are a large, varied family of mostly ground-dwelling frogs from North, Central, and South America, and the West Indies, with a pointed snout and long, powerful hind limbs. Their breeding habits are varied and many lay their eggs in nests of foam.

warty skin

3–4 cm
1¼–1½ in

TÚNGARA FROG
Engystomops pustulosus
During mating, the female of this C. American species produces a secretion that the male whips into a floating foam nest in which the eggs are laid.

horizontal pupils

5–10 cm
2–4 in

AUSTRALIAN GREEN TREEFROG
Litoria caerulea
Found in N.E. Australia and New Guinea, this agile climber is often found close to human habitations.

MANTELLAS

Found only on the islands of Madagascar and Mayotte, the Mantellidae are active by day. Many are brightly coloured, warning predators of powerful toxins in their skin. Most species are threatened by the loss of habitat and by the international pet trade.

5–6 cm
2–2¼ in

ELEGANT MADAGASCAN FROG
Spinomantis elegans
An inhabitant of rocky outcrops, this frog is found at high altitudes, even above the tree line. It breeds in streams.

6–8 cm
2¼–3¼ in

CORONATED TREEFROG
Anotheca spinosa
Native to Mexico and C. America, this large frog lives in bromeliads and banana plants, laying its eggs in water-filled cavities.

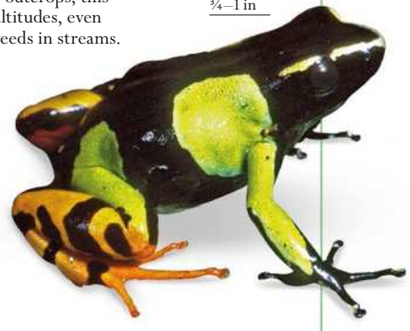
4.5–8 cm
1¾–3¼ in

WHITE-LIPPED BRIGHT-EYED FROG
Boophis albilabris
This large arboreal frog, found only in Madagascar, lives near the streams in which it breeds. It has fully webbed hind feet.

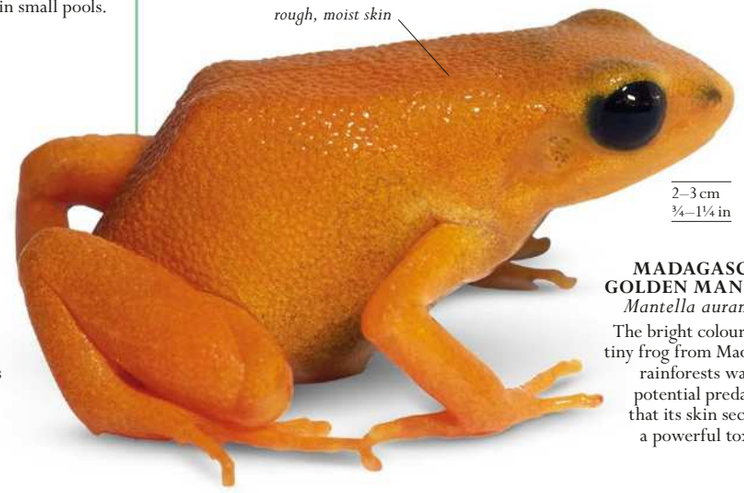
4–8 cm
1½–3¼ in

MASKED TREEFROG
Smilisca phaeota
Active only at night, this inhabitant of humid forests in C. and S. America lays its eggs in small pools.

2–2.5 cm
¾–1 in



rough, moist skin



2–3 cm
¾–1¼ in

MADAGASCAN GOLDEN MANTELLA
Mantella aurantiaca
The bright colour of this tiny frog from Madagascan rainforests warns potential predators that its skin secretes a powerful toxin.

PAINTED MANTELLA
Mantella madagascariensis
This Madagascan frog breeds in forest streams. It is under threat due to loss of habitat. The male's call consists of short chirps.

bony projection

5–7.5 cm
2–3 in

YUCATAN CASQUE-HEADED TREEFROG
Triprion petasatus
An inhabitant of lowland forests in Mexico and C. America, this frog retreats into tree-holes, using the bony projection on its head to seal the opening.

NARROW-MOUTHED FROGS

Frogs of the large and diverse family Microhylidae are found in the Americas, Asia, Australia, and Africa. Most are ground-dwelling and some live in burrows. Most have a short snout, a plump, often teardrop-shaped, body, and stout hind legs.

5–7.5 cm
2–3 in

PAINTED TOAD
Kaloula pulchra
Widespread in Asia, this species has adapted well to human settlements. It protects itself with a noxious, sticky skin secretion.

8–12 cm
3¼–4¾ in

TOMATO FROG
Dyscophus antongilii
Native to Madagascar, this frog stays buried in soil by day, emerging to feed at night. A sticky skin secretion protects it against predators.

3–6 cm
1¼–2¼ in

BLACK-SPOTTED NARROW-MOUTHED FROG
Kalophrynus pleurostigma
This frog from the Philippines protects itself by producing a sticky secretion. It breeds in small pools after rain.

2–3.5 cm
¾–1½ in

EASTERN NARROW-MOUTHED TOAD
Gastrophryne carolinensis
Found in the S.E. USA, this burrowing toad breeds in water bodies of all sizes. The male's call sounds like a bleating lamb.

2–2.5 cm
¾–1 in

GIANT STUMP-TOED FROG
Stumpffia grandis
This small terrestrial frog is found in leaf litter in high-altitude forests in Madagascar.

MEGOPHRYIDAE

Found across Asia, this is a small family of frogs whose body shape and colour patterns enable them to be camouflaged among leaves. They walk rather than jump, and most are ground-living.

ASIAN HORNED FROG
Pelobatrachus nasuta
This frog conceals itself among dead leaves, while it waits for prey. Females lay their eggs under rocks and logs in streams.

7–14 cm
2¾–5½ in

PARSLEY FROGS

Made up of only four species, the family Pelodytidae is confined to Europe and the Caucasus. Named for the green markings on their skin, parsley frogs breed after rain, laying their eggs in broad strips.

3–5 cm
1¼–2 in

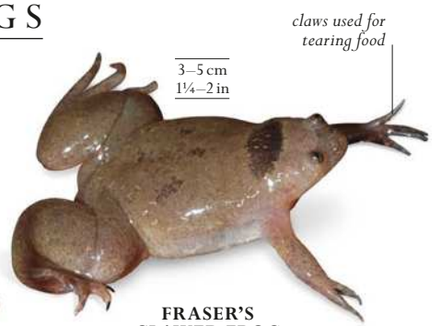
COMMON PARSLEY FROG
Pelodytes punctatus
When climbing smooth, vertical surfaces, this European frog uses its underside as a sucker. Both sexes call during breeding.

TONGUELESS FROGS

These aquatic frogs are well adapted to life in water: they have a flattened body, fully webbed hind feet, and eyes that protrude upwards, enabling them to see above the surface. As their common name suggests, the Pipidae lack a tongue. They feed on a wide range of prey and scavenge on dead animals.

2.5–4.5 cm
1–1¾ in

DWARF SURINAM TOAD
Pipa parva
In this wholly aquatic species found in Venezuela and Colombia, the eggs develop on the female's back.



3–5 cm
1¼–2 in

FRASER'S CLAWED FROG
Xenopus fraseri
Found in W. and C. Africa, this wholly aquatic frog thrives in human-altered habitats and is harvested by people for food.

SPADEFOOT TOADS

A small family found in Eurasia and North Africa, the Pelobatidae are characterized by horny projections on their hind feet. They use them to burrow into the ground, where they wait for rain.

4–8 cm
1½–3¼ in

COMMON SPADEFOOT TOAD
Pelobates fuscus
Found in Europe and Asia, this species is variable in colour. It has a plump body, which it inflates when attacked.

DICROGLOSSIDAE

This diverse family of frogs is found across Africa, Asia, and several Pacific islands.Most are ground-living, but are found close to water. Many lay their eggs in water and have free-living tadpoles.

INDIAN BULLFROG
Hoplobatrachus tigerinus
This large, voracious feeder from S. Asia breeds during the monsoon. The male has a particularly loud call.

6.5–17 cm
2½–6½ in

RAJAMALLY WART FROG
Fejervarya kirtisinghei
Found only in Sri Lanka, this frog lives in leaf litter near streams and thrives in plantations and gardens.

2.5–4.5 cm
1–1¾ in

4–6.5 cm
1½–2½ in

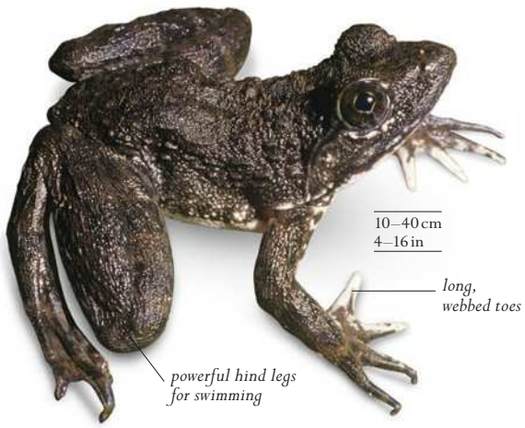
COMMON SKITTERING FROG
Euphlyctis cyanophlyctis
Widespread in S. Asia, this aquatic frog is noted for its ability to skitter over the surface of water.

MARTEN'S PUDDLE FROG
Occidozyga martensii
Found in China and S.E. Asia, this small frog occurs in pools near forest streams and rivers.

1.5–2 cm
½–¾ in

GOLIATH FROGS

The family Conrauidae comprises six species of large, semi-aquatic frogs from Africa that live and breed in fast-flowing rivers and streams. Males are thought not to call, and females lay their eggs among gravel and rocks on the riverbed.



GOLIATH FROG
Conraua goliath
The world's largest frog, this W. African species has an aquatic lifestyle; its powerful legs and webbed feet make it a strong swimmer.

TRUE FROGS

Known as true frogs, this large family is found in most parts of the world. Most of the Ranidae have powerful hind limbs that enable them to jump athletically on land and to swim powerfully in water. They typically breed in early spring, with many laying their eggs communally.

8–12 cm
3¼–4¾ in

EDIBLE FROG
Pelophylax esculentus
This frog is a hybrid between the widespread European *Pelophylax lessonae* and other more local species. It lives in and close to water.

6–7 cm
2¼–2¾ in

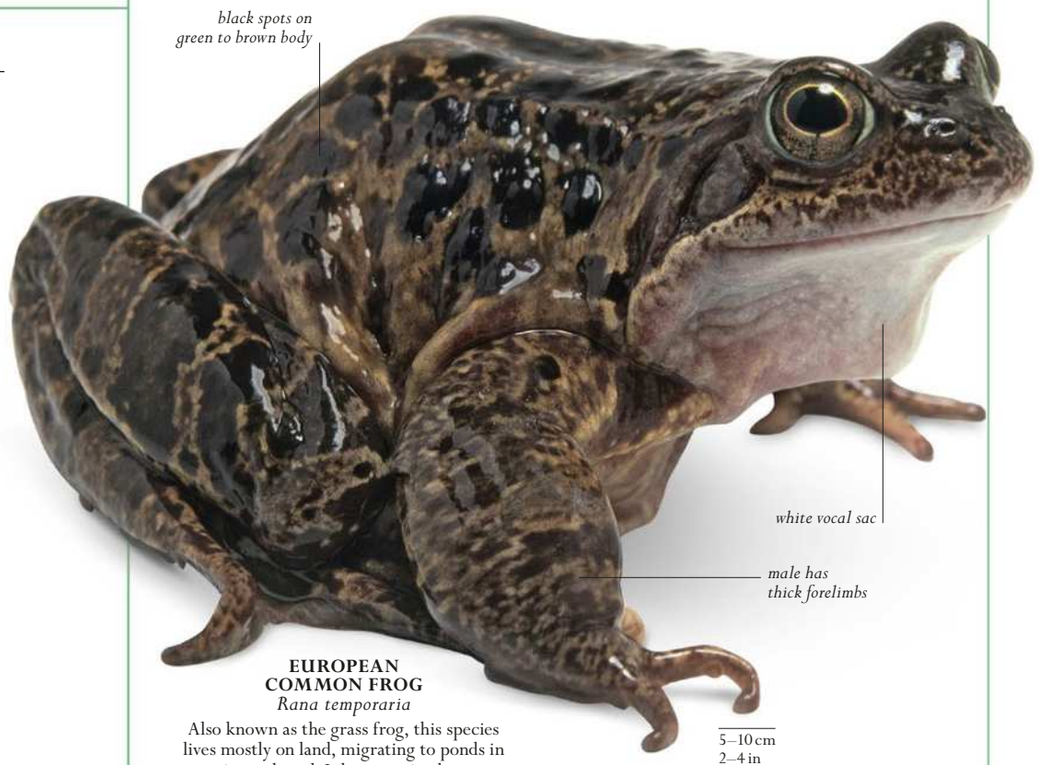
PICKEREL FROG
Rana palustris
Found over much of N. America, this frog breeds in spring, with females laying their eggs in clumps containing two to three thousand eggs.

3.5–8 cm
1½–3¼ in

WOOD FROG
Rana sylvaticus
The only American frog found north of the Arctic Circle, it breeds in early spring in temporary pools free of fish.

9–20 cm
3½–8 in

AMERICAN BULLFROG
Rana catesbeianus
This voracious predator has tadpoles that may take four years to develop, reaching a large size. It is the largest N. American frog.



EUROPEAN COMMON FROG
Rana temporaria
Also known as the grass frog, this species lives mostly on land, migrating to ponds in spring to breed. It lays eggs in clumps.

5–10 cm
2–4 in

PHRYNOBATRACHIDAE

This family of small, terrestrial or semi-aquatic frogs is confined to sub-Saharan Africa. Most breed throughout the year, laying their eggs in water. They reach maturity in five months.

GOLDEN PUDDLE FROG
Phrynobatrachus auritus
This frog is so named because it breeds in very small pools. A ground-dwelling species, it is found in C. African rainforests.

ORNATE FROGS AND GRASS FROGS

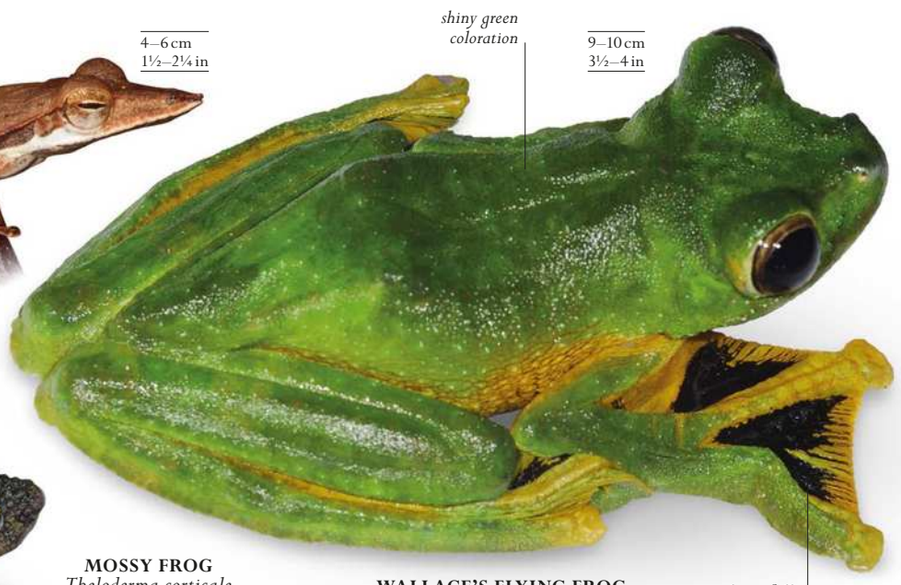
Found in open country in Africa, Madagascar, and the Seychelles, the Ptychadenidae include many brightly coloured frogs. A streamlined body and strong hind legs make them prodigious jumpers.

MASCARENE RIDGED FROG
Ptychadena mascareniensis
Common on agricultural land, this frog has long legs and a pointed snout. It breeds in puddles, wheel ruts, and ditches.

AFRO-ASIAN TREEFROGS

The Rhacophoridae range across Africa and much of Asia, and are mostly arboreal frogs. The family also includes flying frogs that glide from one tree to another. Many lay their eggs in foam nests, where the eggs and tadpoles stay protected against predators.

SOUTHERN WHIPPING FROG
Taruga longinasus
Endangered by the loss of much of its habitat, this arboreal frog occurs in Sri Lanka's remaining patches of rainforest.



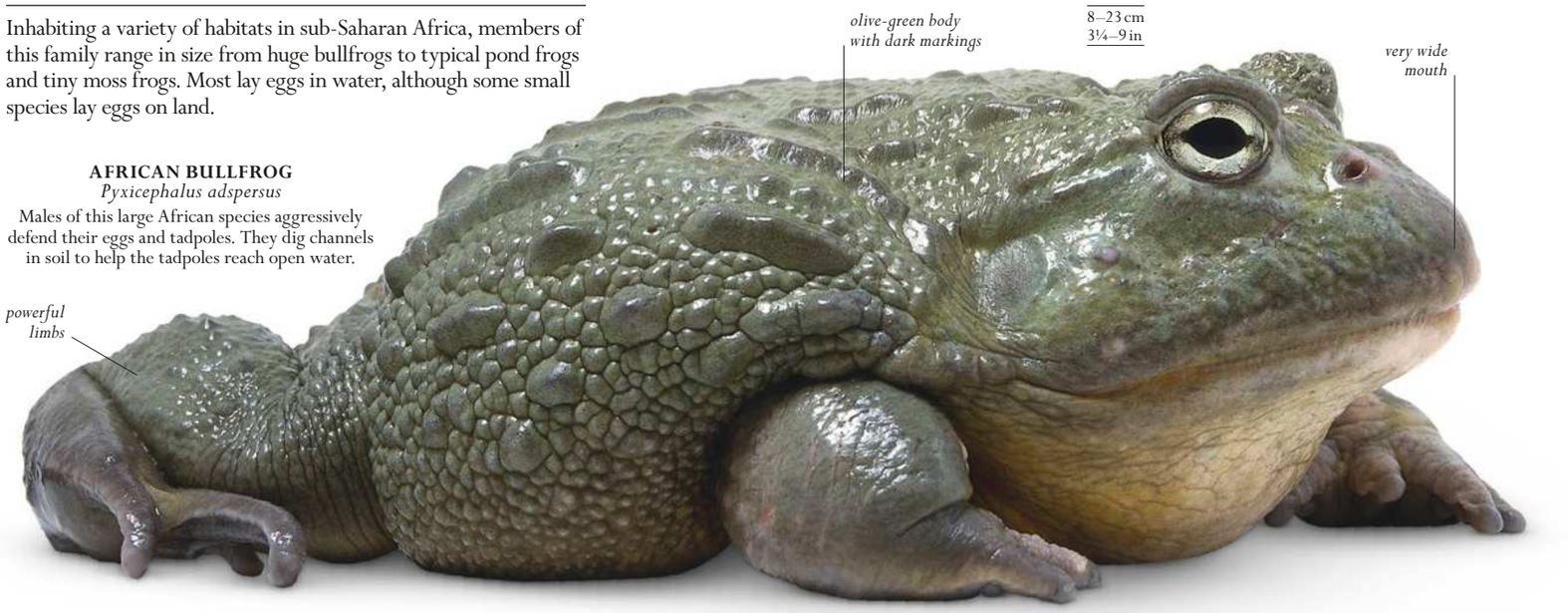
AFRICAN FOAM-NEST TREEFROG
Chiromantis rufescens
Found in the forests of W. and C. Africa, this frog lays its eggs in a foam nest attached to a branch overhanging water.

MOSSY FROG
Theloderma corticale
The warty skin and green colour of this Vietnamese frog camouflages it against moss. It curls into a ball when threatened.

WALLACE'S FLYING FROG
Rhacophorus nigropalmatus
This arboreal species from the rainforests of S.E. Asia has webbed feet that enable it to glide between trees.

PYXICEPHALIDAE

Inhabiting a variety of habitats in sub-Saharan Africa, members of this family range in size from huge bullfrogs to typical pond frogs and tiny moss frogs. Most lay eggs in water, although some small species lay eggs on land.



AFRICAN BULLFROG
Pyxicephalus adspersus
Males of this large African species aggressively defend their eggs and tadpoles. They dig channels in soil to help the tadpoles reach open water.

MEXICAN BURROWING TOAD

The only member of the family Rhinophrynidae, the burrowing toad specializes in digging in soil and eating ants. It has a long, thin tongue that it sticks out of its narrow mouth.

6–8 cm
2¼–3¼ in

MEXICAN BURROWING TOAD
Rhinophrynus dorsalis
This unusually shaped toad spends most of its life burrowing underground, emerging only after rain to breed in temporary pools.

AMERICAN SPADEFOOT TOADS

This family consists of toads that live on dry land and stay inactive underground for long periods. The Scaphiopodidae emerge after rain to breed in temporary pools. These may evaporate quickly, so the tadpoles develop very rapidly.

5.5–9 cm
2¼–3½ in

4–6 cm
1½–2¼ in

PLAINS SPADEFOOT
Spea bombifrons
Found in arid plains of N. America and Mexico, this frog burrows by day. It gathers to breed in large numbers after heavy rain.

COUCH'S SPADEFOOT
Scaphiopus couchii
This N. American frog lives in arid areas, spending much of its time underground. It emerges at night to feed and, after heavy rain, to breed.

STRABOMANTIDAE

Many small frogs native to South America and the Caribbean make up this family. They are all direct developers: there is no tadpole stage and the egg hatches straight into a miniature adult.

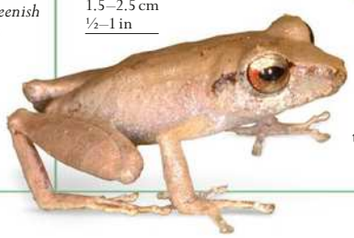
LIMON ROBBER FROG
Pristimantis cerasinus
Hiding in leaf litter by day, but arboreal by night, this small frog is found in humid lowland forests of C. America.

1.5–3.5 cm
½–1½ in

2–4 cm
¾–1½ in

CHIRIQUI ROBBER FROG
Pristimantis cruentus
This small, terrestrial frog, found in C. and S. America, lays its eggs in crevices on tree trunks.

1.5–2.5 cm
½–1 in



PYGMY RAIN FROG
Pristimantis ridens
Found in the forests of C. and S. America, this tiny nocturnal frog thrives in gardens and lays its eggs in leaf litter.

CAECILIANS

Caecilians are long-bodied, limbless amphibians with little or no tail. Ring-shaped folds (annuli) in the skin give them a segmented appearance.

All caecilians live in the tropics. They vary in length from 12 cm (4¾ in) to 1.6 m (5¼ ft). Most live underground, burrowing in soft soil, using their pointed, bony head as a shovel. They emerge at night, especially after rain, to feed on earthworms, termites, and other insects. Others live in water and resemble eels, rarely moving onto the land. These have a fin on the tail. With only rudimentary eyes, all rely on smell to find food and mates. A pair of retractable tentacles between the eyes and the nostrils transmit chemical signals to the nose.

In all caecilians, the eggs are fertilized internally. Some species lay eggs, but in others the eggs are retained inside the female's body. The young emerge either as gilled larvae or as small adults.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	GYMNOPHIONA
FAMILIES	10
SPECIES	214

50 cm
20 in

PURPLE CAECILIAN
Gymnopis multiplicata
This terrestrial caecilian from C. America lives in a wide range of habitats. The eggs hatch inside the female.

ICHTHYOPHIIDAE

Found in Asia, these caecilians lay eggs in soil near water. Females remain with their clutches, defending them until the larvae have made their way to open water.

33 cm
13 in

KOH TAO CAECILIAN
Ichthyophis kohtaoensis
Found in a variety of habitats in S.E. Asia, this caecilian lays its eggs on land, but its larvae live in water.

DERMOPHIIDAE

These thick-set, cylindrical caecilians from Africa live beneath the surface and are mostly brown, grey, or dark purple in colour but may be yellow. Some species lack eyes. They give birth to live young.

CAECILIIDAE

Most species in this family are burrowers. Found in most tropical regions of the world, they vary greatly in length, some growing to over 1.5 m (5 ft). In some the eggs hatch into larvae; in others the larvae develop inside the female.

37–91 cm
14½–36 in

SANTA ROSA CAECILIAN
Caecilia attenuata
A rarely seen, greyish blue, burrowing species from the moist lowland forests of Amazonian Ecuador, this caecilian also occurs in degraded habitats including plantations and gardens.

SALAMANDERS AND NEWTS

Unlike their fellow amphibians, the frogs, salamanders and newts normally have a slender, lizard-like body, a long tail, and four legs similar in size.

Newts and salamanders, also known as urodeles, are generally found in damp habitats and are largely confined to the northern hemisphere. They are numerous in the Americas, ranging from Canada to northern South America. They vary considerably in size, from species over 1 m (3¼ ft) in length, to tiny creatures about 2 cm (¾ in) long.

AMPHIBIOUS LIFESTYLES

Some species, notably the newts, spend part of their life in water, part on land. Some salamander species live their entire lives in water, while others are wholly terrestrial. Most have smooth, moist skin through which they breathe to a greater or lesser extent.

The salamanders of one family, the plethodontids, have no lungs and breathe entirely through their skin and the roof of their mouth. Urodeles have a relatively small head, compared with frogs and toads; they also have smaller eyes, smell being the most important sense used in finding food and in social interactions. Most species, especially the terrestrial ones, are nocturnal, hiding under a log or rock during the day.

REPRODUCTION

In the majority of species, the eggs are fertilized inside the female. Males, however, do not have a penis but package sperm in capsules called spermatophores which are passed to the female during mating. In many species sperm transfer is preceded by elaborate courtship in which the male induces the female to co-operate with him. She may, of course, reject his advances. In many newts, males develop dorsal crests and bright colours in the breeding season.

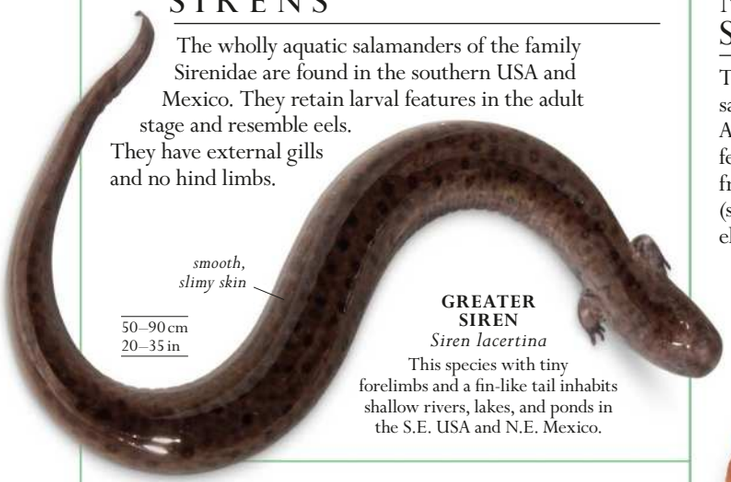
Many species lay their eggs in water. When the larvae hatch, they have a long, slender body, a deep, fin-like tail, and large, feathery external gills. The larvae are carnivorous, feeding on tiny water creatures. The exceptions to this rule are the wholly terrestrial species of salamander. These lay their eggs on land and the larval stage is completed within the egg, which hatches to produce a miniature adult.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	CAUDATA
FAMILIES	10
SPECIES	754

A male alpine newt sniffs a female before courting her. Odour helps to identify the gender and species of potential partners.

SIRENS

The wholly aquatic salamanders of the family Sirenidae are found in the southern USA and Mexico. They retain larval features in the adult stage and resemble eels. They have external gills and no hind limbs.



GREATER SIREN
Siren lacertina
This species with tiny forelimbs and a fin-like tail inhabits shallow rivers, lakes, and ponds in the S.E. USA and N.E. Mexico.

TORRENT SALAMANDERS

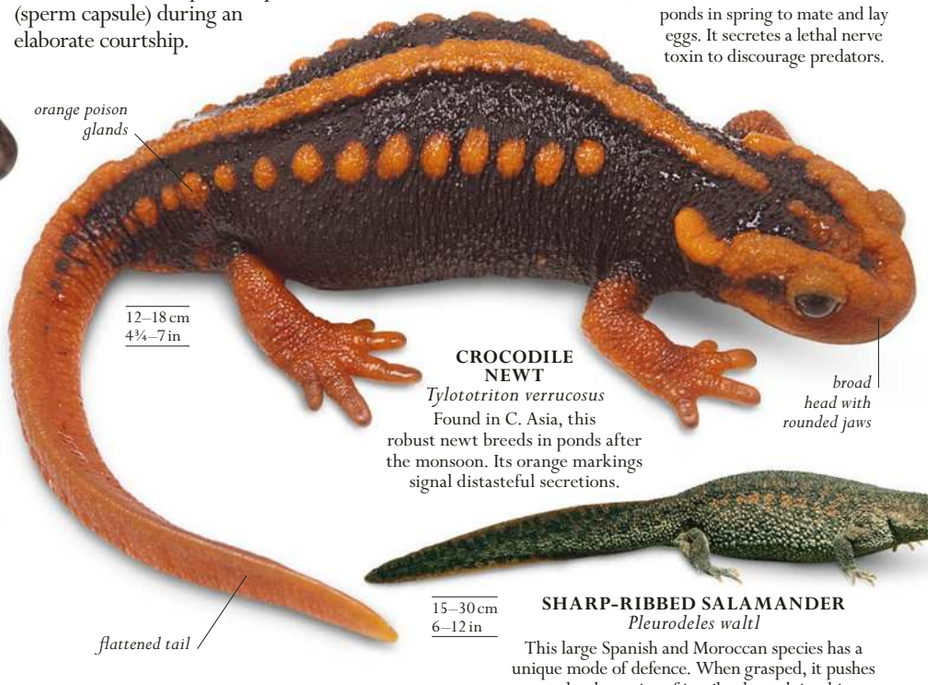
Confined to the extreme northwestern USA, the Rhyacotritonidae are a small family of four species. These stocky, semi-aquatic salamanders lay their eggs on rocks under water and have aquatic larvae.

COLUMBIA TORRENT SALAMANDER
Rhyacotriton kezeri
Confined to the forests of Oregon and Washington, this salamander lays its eggs in springs. Intensive logging has caused its numbers to decline considerably.

NEWTS AND EUROPEAN SALAMANDERS

The Salamandridae are small- and medium-sized salamanders and newts found in Europe, North Africa, Asia, and North America. Eggs are fertilized inside the female, with sperm being transferred from the male in a spermatophore (sperm capsule) during an elaborate courtship.

CALIFORNIA NEWT
Taricha torosa
This nocturnal newt enters ponds in spring to mate and lay eggs. It secretes a lethal nerve toxin to discourage predators.

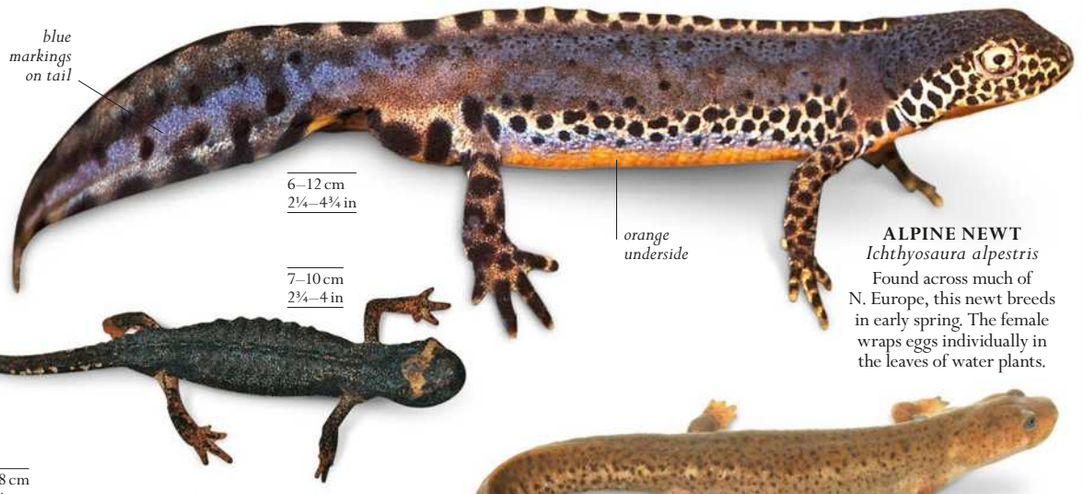


CROCODILE NEWT
Tylototriton verrucosus
Found in C. Asia, this robust newt breeds in ponds after the monsoon. Its orange markings signal distasteful secretions.

SHARP-RIBBED SALAMANDER
Pleurodeles waltl
This large Spanish and Moroccan species has a unique mode of defence. When grasped, it pushes out the sharp tips of its ribs through its skin.

18–28 cm
7–11 in

FIRE SALAMANDER
Salamandra salamandra
This European salamander spends most of its time on land, entering water only to lay eggs. The glands on its head can spray a toxic secretion at enemies.



6–12 cm
2¼–4¾ in

7–10 cm
2¾–4 in

ALPINE NEWT
Ichthyosaura alpestris
Found across much of N. Europe, this newt breeds in early spring. The female wraps eggs individually in the leaves of water plants.

SPECTACLED SALAMANDER
Salamandrina terdigitata
This secretive salamander is found only in Italy and lives in streams in hilly areas. It has a long, slender, and flattened body.

13–17 cm
5–6½ in

SPOTLESS STOUT NEWT
Paramesotriton labiatus
Found in mountain streams in China, this newt is equipped with a large tail for swimming. It attaches its eggs to rocks.

10–14 cm
4–5½ in

SARDINIAN BROOK SALAMANDER
Euproctus platycephalus
Found only in Sardinia, this slender salamander lives in streams, laying its eggs under rocks. It is endangered due to degradation of its habitat.

9–13 cm
3½–5 in

LORESTAN NEWT
Neurergus kaiseri
Found only in Iran, this species lives in streams. It is critically endangered due to loss of its habitat and its popularity as a pet.

6.5–14 cm
2½–5½ in

EASTERN NEWT
Notophthalmus viridescens
This pond-breeding newt is from eastern N. America. Juveniles, or "efts", are terrestrial, bright red in colour, and very toxic.

9–12 cm
3½–4¾ in

JAPANESE NEWT
Cynops pyrrhogaster
This newt spends much of its life in water. Its brightly coloured belly warns potential predators that the glands in its skin secrete a toxin.

7–10 cm
2¾–4 in

SMOOTH NEWT
Lissotriton vulgaris
Common across Europe and W. Asia, this small amphibian breeds in ponds. The male mates with the female after elaborate courtship.

10–18 cm
4–7 in

GREAT CRESTED NEWT
Triturus cristatus
Found across Europe and C. Asia, males of this large, pond-breeding species develop a spectacular dorsal crest in spring, and display it vigorously to potential mates.

10–14 cm
4–5½ in

MARBLED NEWT
Triturus marmoratus
Found in France and Spain, this newt lives in woodland, heathland, and hedgerows. It enters ponds to breed in spring.

LUNGLESS SALAMANDERS

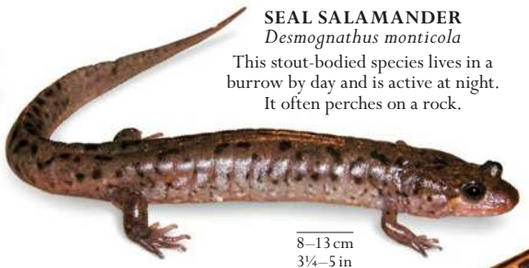
Containing over 390 species, the Plethodontidae are the largest salamander family. Members of this family have no lungs, but breathe through their mouth and skin. Apart from six European species, all live in North, Central, and South America, inhabiting a wide variety of habitats and feeding mainly on small invertebrates.

8–13 cm
3¼–5 in

STRIATED SALAMANDER
Bolitoglossa striatula
A small salamander with webbed digits, this species is nocturnal, hiding by day among banana leaves. It is found in Costa Rica, Honduras, and Nicaragua.

7–11 cm
2¾–4¼ in

MOUNTAIN DUSKY SALAMANDER
Desmognathus ochrophaeus
Mostly terrestrial, this salamander is often found foraging in forests in large numbers after heavy rain, and sometimes climbing trees and shrubs.



SEAL SALAMANDER
Desmognathus monticola
This stout-bodied species lives in a burrow by day and is active at night. It often perches on a rock.

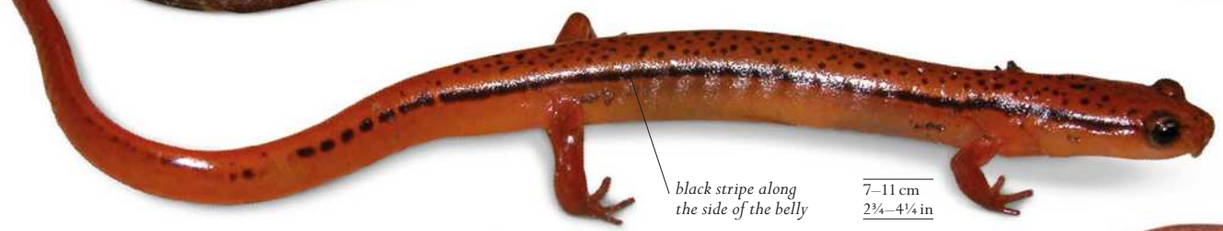
8–13 cm
3¼–5 in

11–15 cm
4¼–6 in

ALLEN'S WORM SALAMANDER
Oedipina alleni
Found in leaf litter in lowland forests of Costa Rica, this salamander coils up its elongated body and tail when attacked.

10–16 cm
4–6½ in

THREE-LINED SALAMANDER
Eurycea guttolineata
Found in and around water, the slender three-lined salamander is a very good swimmer, but spends much of its time in a burrow.



7–11 cm
2¾–4¼ in

BLUE RIDGE TWO-LINED SALAMANDER
Eurycea wilderae
Found around springs and streams, this small species is common in the wooded mountains of the S. Appalachians. It mates in autumn and lays its eggs in winter.

11.5–21 cm
4½–8½ in

MISSISSIPPI SLIMY SALAMANDER
Plethodon mississippi
Found in hardwood forests, this terrestrial salamander protects itself from predators by producing a sticky skin secretion. It lays its eggs on land.

7–12 cm
2¾–4¾ in

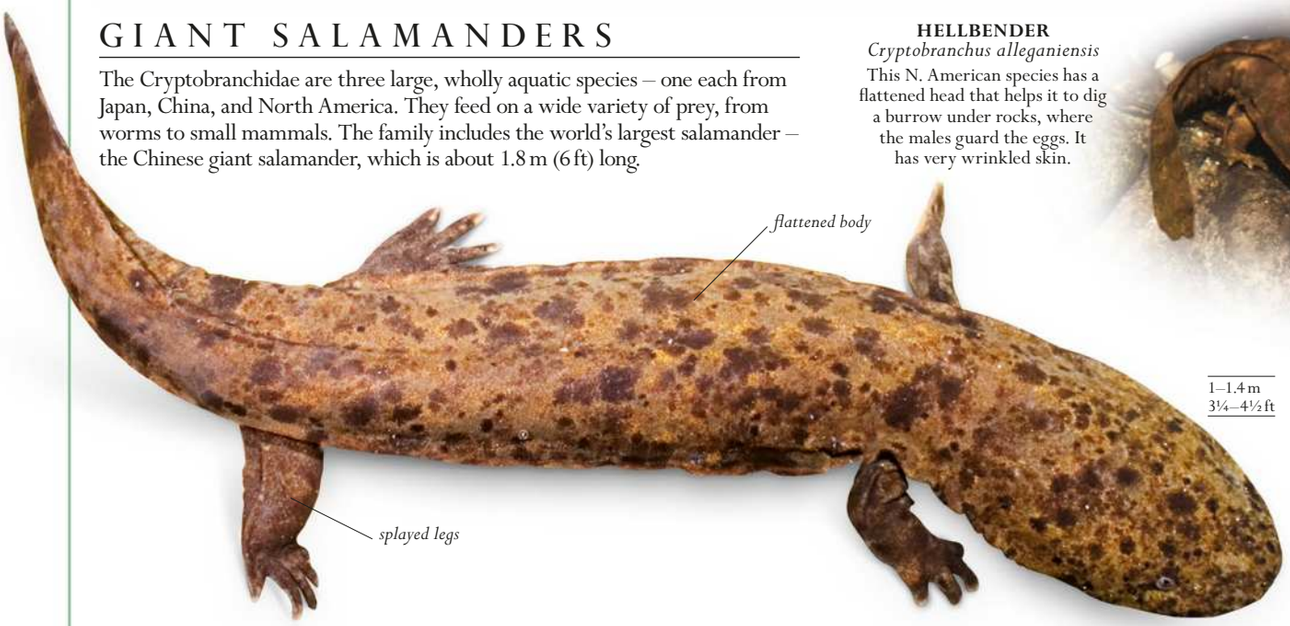
RED-BACKED SALAMANDER
Plethodon cinereus
A terrestrial species, this salamander hides under bark by day and hunts for insects and other prey in foliage after dark.

GIANT SALAMANDERS

The Cryptobranchidae are three large, wholly aquatic species – one each from Japan, China, and North America. They feed on a wide variety of prey, from worms to small mammals. The family includes the world's largest salamander – the Chinese giant salamander, which is about 1.8 m (6 ft) long.

HELLBENDER
Cryptobranchus alleganiensis
This N. American species has a flattened head that helps it to dig a burrow under rocks, where the males guard the eggs. It has very wrinkled skin.

30–75 cm
12–30 in



1–1.4 m
3¼–4½ ft

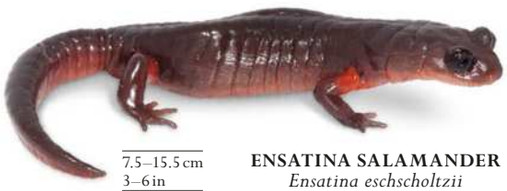
JAPANESE GIANT SALAMANDER
Andrias japonicus
This aquatic species is threatened by degradation of its habitat. Some males, called "den masters", defend burrows in which females lay eggs.

12–19 cm
4¾–7½ in

SPRING SALAMANDER
Gyrinophilus porphyriticus
An agile inhabitant of mountain streams and springs, this colourful salamander is most commonly found hiding under a log or rock.

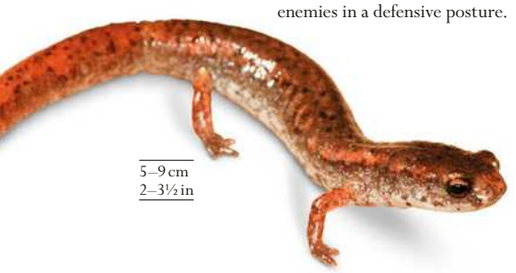
7–12 cm
2¾–4¾ in

ITALIAN CAVE SALAMANDER
Hydromantes italicus
Found near streams and springs in the mountains of N. Italy, this salamander lives in caves and rock crevices.



7.5–15.5 cm
3–6 in

ENSATINA SALAMANDER
Ensatina eschscholtzii
This smooth-skinned, N. American salamander has a plump tail, which is narrow at the base. It waves its tail at enemies in a defensive posture.



5–9 cm
2–3½ in

FOUR-TOED SALAMANDER
Hemidactylium scutatum
A terrestrial salamander, the adults of this species live in mosses, but the larvae grow in water. There is a marked narrowing at the base of its tail.

ASIATIC SALAMANDERS

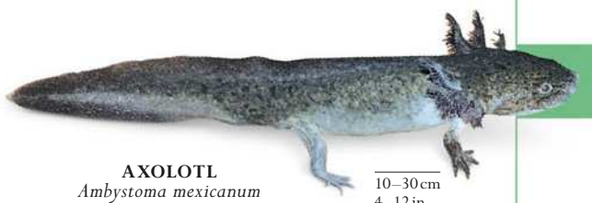
Around 50 small- to medium-sized species form the Hynobiidae. They are confined to Asia, with some found in mountain streams. They lay their eggs in ponds or streams, and their larvae have external gills. Some species have claws to grasp rocks.

10–16 cm
4–6½ in

OITA SALAMANDER
Hynobius dunni
Females of this endangered Japanese species produce eggs in sacs, and males then compete to fertilize them externally.

MOLE SALAMANDERS

These large creatures mostly live in burrows and emerge to forage by night. The Ambystomatidae comprises 33 species, all found in North America. Some species, notably the Mexican axolotl, are aquatic as adults and retain larval features, such as external gills.



10–30 cm
4–12 in

AXOLOTL
Ambystoma mexicanum
Adult axolotls never leave the water and resemble very large salamander larvae, with their deep tail and feathery external gills.

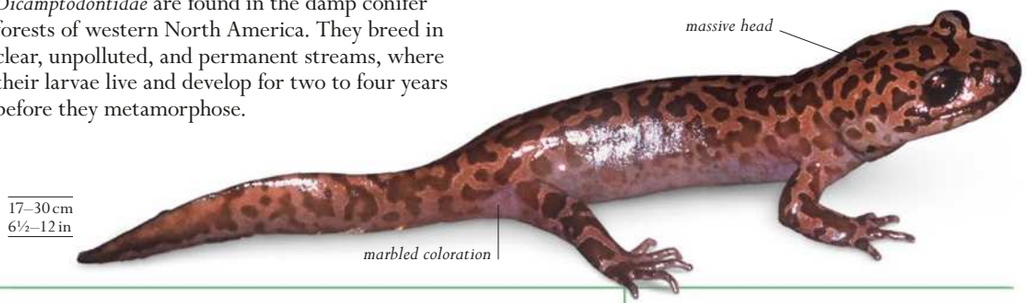
TIGER SALAMANDER
Ambystoma tigrinum
A thick-set salamander found throughout much of N. America, this species migrates in spring to ponds to mate and lay eggs.

MARBLED SALAMANDER
Ambystoma opacum
This short-tailed, stocky salamander breeds in autumn and lays its eggs in dried-up ponds that fill with rain in winter.

AMERICAN GIANT SALAMANDERS

The four large and aggressive species of the *Dicamptodontidae* are found in the damp conifer forests of western North America. They breed in clear, unpolluted, and permanent streams, where their larvae live and develop for two to four years before they metamorphose.

CALIFORNIA GIANT SALAMANDER
Dicamptodon ensatus
This large, nocturnal salamander is threatened by loss and degradation of its forest habitat.This species has an aquatic larval stage.

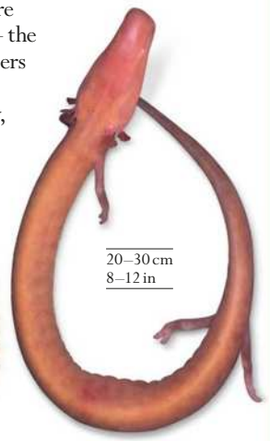


MUDPUPPIES AND RELATIVE

Five of the six species in the Proteidae are found in North America; the sixth one – the cave-living olm – lives in Europe. Members of this family retain the larval form into their adult life, with a long, slender body, external gills, and small eyes.

20–50 cm
8–20 in

MUDPUPPY
Necturus maculosus
A voracious predator, the mudpuppy, or waterdog, feeds on a variety of invertebrates, fish, and amphibians. The female aggressively defends her developing eggs.



20–30 cm
8–12 in

OLM
Proteus anguinus
The wholly aquatic olm lives in dark, flooded caves in Slovenia and Montenegro. It is blind and has white, pink, or grey skin.

AMPHIUMAS

Occurring in eastern North America, the Amphiumidae are a family of three large, wholly aquatic salamanders with an eel-like body and tiny limbs. Females guard the eggs in a nest on land. Amphiumas can survive drought by burrowing into mud and forming a cocoon. They feed on worms, molluscs, fish, snakes, and small amphibians.

40–110 cm
16–43 in

THREE-TOED AMPHIUMA
Amphiuma tridactylum
This large salamander, with slimy skin and a long tail, can give a painful bite. Males breed every year, while females breed in alternate years.

REPTILES

Reptiles are a sophisticated, diverse, and successful group of ectothermic (cold-blooded) vertebrates. Although commonly associated with hot, dry environments, they are found in a wide range of habitats and climates around the world.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDERS	4
FAMILIES	92
SPECIES	11,050

Reptile scales are a protective layer of skin with overlapping patches thickened with keratin and sometimes bone.

The shelled egg allows reptiles to reproduce out of water. The outer layer protects the embryo from dehydration.

Crocodiles can walk with their body raised well off the ground, whereas turtles manage only a sprawling gait.

Reptiles modify their behaviour to regulate body temperature. They bask in the morning sun to absorb heat energy.

The first reptiles evolved from amphibians more than 295 million years ago. They are the ancestors not only of modern-day reptiles but also of mammals and birds. During the Mesozoic Era, reptiles such as dinosaurs, aquatic ichthyosaurs and plesiosaurs, and aerial pterosaurs dominated Earth. Reptile groups that still exist today evolved in this period and survived the mass extinction event that killed off the dinosaurs 66 million years ago.

All reptiles share certain characteristics, such as scaly skin and behavioural thermoregulation – using outside sources to maintain a constant body temperature, by basking in the sun, for example. But the various groups exhibit obvious differences. Turtles and tortoises are protected by a unique, heavily armoured shell. Lizards, crocodilians, and tuataras have four limbs and a long tail. Many squamates, or scaled reptiles – lizards, snakes, and amphisbaenians – have evolved limbless forms.

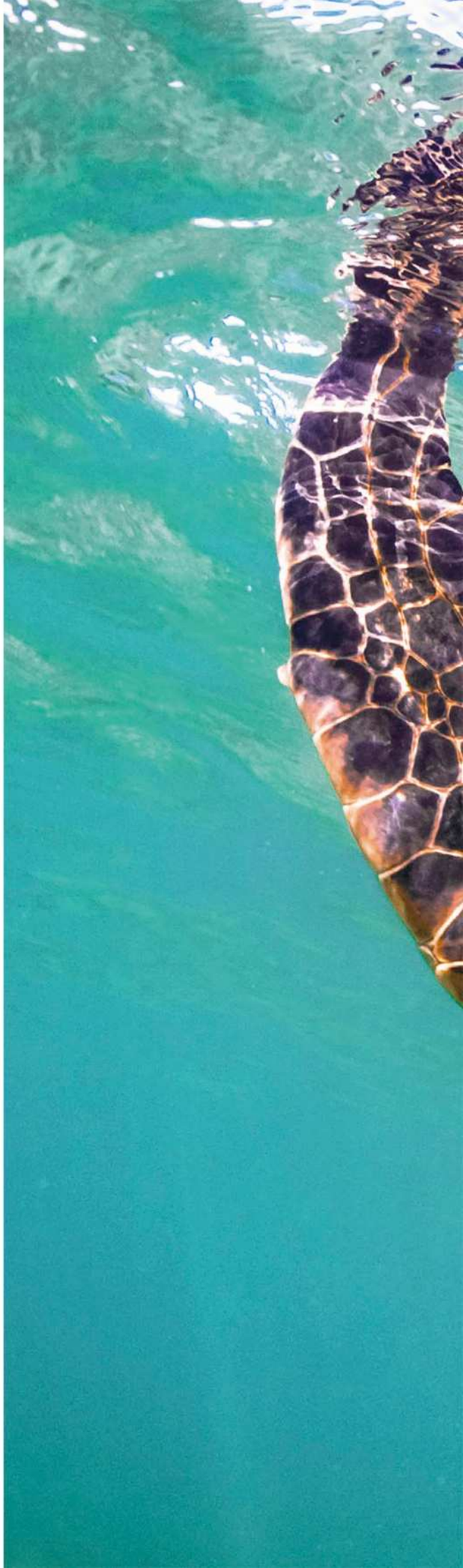
Hot desert ecosystems are typically dominated by lizards and snakes but reptiles of all types are found in all habitats in the tropics and subtropics. Fewer species are found in cooler temperate climates. Within each ecosystem reptiles are important both as predators and as prey. Most are carnivores, feeding on a wide range of other animals. A few large lizards and tortoises are exclusively herbivores, but many species are opportunistic omnivores.

BEHAVIOUR AND SURVIVAL

Some species are solitary whereas others are highly social. Although sluggish and inactive when cool, once their preferred body temperature is reached by basking or pressing against a warm rock, they can be very active.

Reproductive behaviour can be complex, with males actively defending territories and courting females. Although some squamates give birth to live young, in most cases the male reptile fertilizes the female, who then lays eggs in an underground nest. All reptiles are independent and self-feeding from birth, although some crocodilians give parental care for two or more years.

Reptiles are exploited by humans for their skin or as food. This, along with habitat loss, pollution, and climate change, threatens the survival of many species.



SEA TURTLE IN ITS ELEMENT >
The green turtle may appear primitive but, with efficient flippers and a flattened shell, is well adapted to its aquatic life.

REPTILE GROUPS

By the Mesozoic Era, reptiles had diversified. Turtles and crocodilians had diverged early on, and later the squamates – lizards, snakes, and amphisbaenians – appeared.

TURTLES AND TORTOISES
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TUATARA
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LIZARDS
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AMPHISBAENIANS
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TURTLES AND TORTOISES

With their bony shell, stout limbs, and toothless, beak-like mouth, turtles and tortoises have changed little from species that lived 200 million years ago.

The order includes sea turtles, freshwater turtles, and terrestrial tortoises. Some extinct turtles were gigantic, but most modern ones are more modestly sized. The exceptions are the large sea turtles and a few terrestrial tortoises inhabiting isolated islands.

PROTECTION AND LOCOMOTION

A turtle's shell is formed of numerous fused bones, overlaid by scutes. The domed upperpart is known as the carapace and the lower part, the plastron. Scutes are horny plates and new ones form beneath the old ones each year. The degree of protection provided by the shell varies between species and is much reduced in some aquatic turtles. Not all species can retract the head into the shell – some tuck their head along one shoulder under the edge of the shell.

Tortoises are slow animals, but some sea turtles can reach speeds of 30 kph (19 mph) when swimming, as a result of the modification of their forelimbs into flippers. Although they need to breathe air, many turtles are tolerant of low oxygen levels and can remain submerged for hours. Turtles have a slow metabolism and are generally long lived.

Some species are carnivores, others herbivores, but most turtles are omnivorous. Animal prey is either slow moving or ambushed as the turtle lies hidden. Food is broken up by the "beak", a sharp, keratinous jaw covering.

NESTING AND BREEDING

Turtles do not defend territories, but they can have extensive home ranges and may develop social hierarchies. Otherwise turtles often congregate on river banks or lakesides to bask or nest.

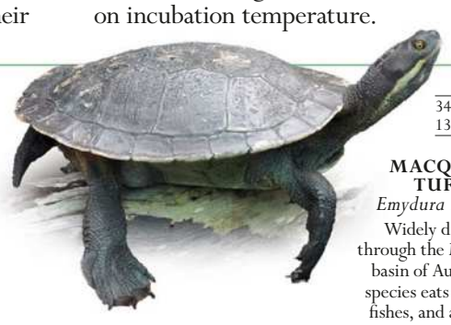
Both in water and on land, males of some species engage in elaborate courtship of females before copulation. Fertilization is internal and the females lay shelled eggs, like those of other reptiles and birds. These are spherical or elongated, with rigid or flexible shells. Clutches are laid in nests dug up by the female in terrestrial sites. Nearly all marine species come to land only to nest. In many species, but not all, the gender of the hatchlings depends on incubation temperature.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	TESTUDINES
FAMILIES	14
SPECIES	353

A green sea turtle hatchling enters the sea. Many of its breeding beaches are protected, but it remains endangered.

AUSTRO-AMERICAN SIDE-NECKED TURTLES

From South America and Australasia, the Chelidae include carnivorous and omnivorous species. Their characteristically long neck cannot be retracted, so it is turned sideways under the edge of the shell. They lay elongated eggs with leathery shells.



34 cm
13½ in

MACQUARIE TURTLE
Emydura macquarii
Widely distributed through the Murray River basin of Australia, this species eats amphibians, fishes, and algae. Males are smaller than females.

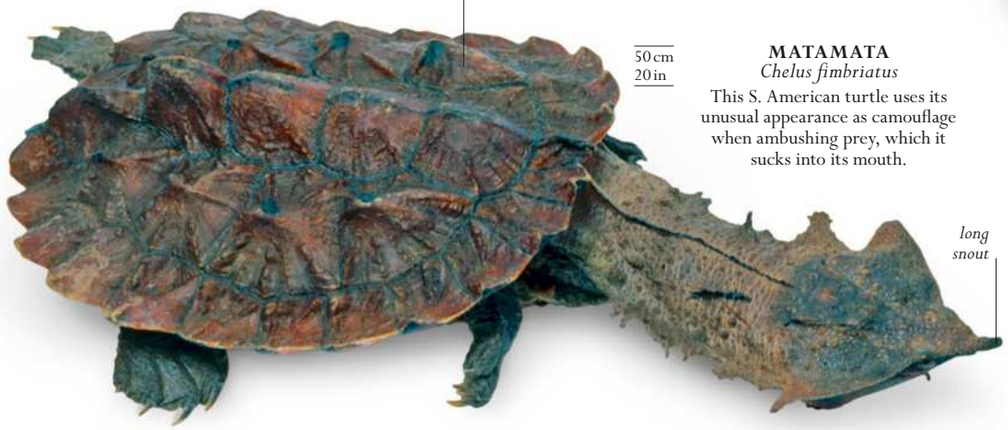
75 cm
30 in

REIMANN'S SNAKE-NECKED TURTLE
Chelodina reimanni
This turtle from New Guinea eats crustaceans and molluscs. When threatened, it tucks its large head under the side of its carapace.

25 cm
10 in

COMMON SNAKE-NECKED TURTLE
Chelodina longicollis
A shy freshwater turtle of Australia, this species has a long neck, which enables it to raise its head out of water and capture prey.

scalloped carapace with keel (central ridge)



50 cm
20 in

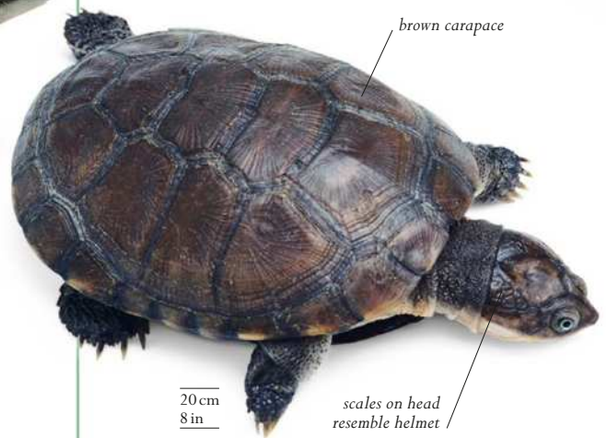
MATAMATA
Chelus fimbriatus
This S. American turtle uses its unusual appearance as camouflage when ambushing prey, which it sucks into its mouth.

long snout

AFRICAN SIDE-NECKED TURTLES

Most of the Pelomedusidae are carnivorous and occupy freshwater habitats. When threatened, they can hide their head and neck beneath the edge of the shell. Found throughout Africa and Madagascar, they survive dry conditions by burying themselves in mud.

brown carapace



20 cm
8 in

scales on head resemble helmet

AFRICAN HELMETED TURTLE
Pelomedusa subrufa
Widespread in sub-Saharan Africa, this carnivorous turtle is highly sociable and often hunts in packs to bring down large prey.

BIG-HEADED TURTLE

The sole member of the Platysternidae, the big-headed turtle is an endangered species from shallow forest streams in southern China and Southeast Asia. It forages in streams, bottom-walking rather than swimming.

18 cm
7 in

BIG-HEADED TURTLE
Platysternon megacephalum
This small, carnivorous turtle has a flattened body, a very large head with powerful jaws, and a long tail.

AMERICAN SIDE-NECKED RIVER TURTLES

Closely related to African side-necked turtles, most species of the family Podocnemididae are found in tropical South America, barring one in Madagascar. These are herbivorous turtles found in various freshwater habitats. They cannot retract their neck into their shell.

RED-HEADED AMAZON RIVER TURTLE
Podocnemis erythrocephala
This species is found in swamps of the Rio Negro region of the Amazon basin in S. America.

32 cm
12½ in

SNAPPING TURTLES

Native to North and Central America, these large, aquatic turtles are noted for their aggression. The Chelydridae have a rough shell and a powerful head, with heavy, crushing jaws. They are effective predators, ambushing a variety of animals, but they also eat plants.

55 cm
22 in

COMMON SNAPPING TURTLE
Chelydra serpentina
A robust turtle, it often lies in wait for prey half-buried in mud. It occupies freshwater habitats from eastern N. America as far south as Ecuador.

massive head with strong jaws and sharp, pointed beak

tongue with worm-like lure

heavily built carapace with three rows of conical scutes

80 cm
32 in

ALLIGATOR SNAPPING TURTLE
Macrochelys temminckii
One of the largest freshwater turtles in the world, this N. American species has a worm-shaped lure on its tongue to attract prey as it lies in wait.

SOFTSHELL TURTLES

These aquatic predators inhabit freshwater habitats in North America, Africa, and southern Asia. The Trionychidae have a flattened shell covered with leathery skin rather than keratinous scutes. The adult shell length ranges in size from 25 cm (10 in) to over 1 m (3¼ ft).

55 cm
22 in

SPINY SOFTSHELL TURTLE
Apalone spinifera
A native of eastern N. America, this species eats mainly insects and aquatic invertebrates.

27 cm
10½ in

INDIAN FLAPSHELL TURTLE
Lissemys punctata
This Indian turtle has a rear flap on either side of the plastron that protects the hind limbs when they are withdrawn into the body.

greyish green carapace with raised ridges

35 cm
14 in

CHINESE SOFT-SHELLED TURTLE
Pelodiscus sinensis
Hunted for its meat, this turtle of E. Asia is rare in its native habitat, but tens of thousands are bred annually on farms.

PIG-NOSED TURTLE

The only species in the family Carettochelyidae, this turtle is an omnivore. Its carapace lacks hard scutes, but is still rigid. Its snout is adapted for breathing air while submerged.

PIG-NOSED RIVER TURTLE
Carettochelys insculpta
This nocturnal turtle is found in New Guinea and N. Australia. Like sea turtles, it has forelimbs modified as flippers for aquatic flight.

AMERICAN MUD AND MUSK TURTLES

These turtles from the New World emit a strong scent when threatened. The Kinosternidae tend to walk along the bottom of lakes and rivers, rather than swim, and are opportunistic omnivores. They lay elongated, hard-shelled eggs.

EASTERN MUD TURTLE
Kinosternon subrubrum
An omnivore, this freshwater turtle feeds on the bottom of slow, shallow watercourses in the S.E. USA.

COMMON MUSK TURTLE
Sternotherus odoratus
This freshwater turtle from eastern N. America is an omnivore. When threatened, it not only exudes a nauseating musk, but also bites.

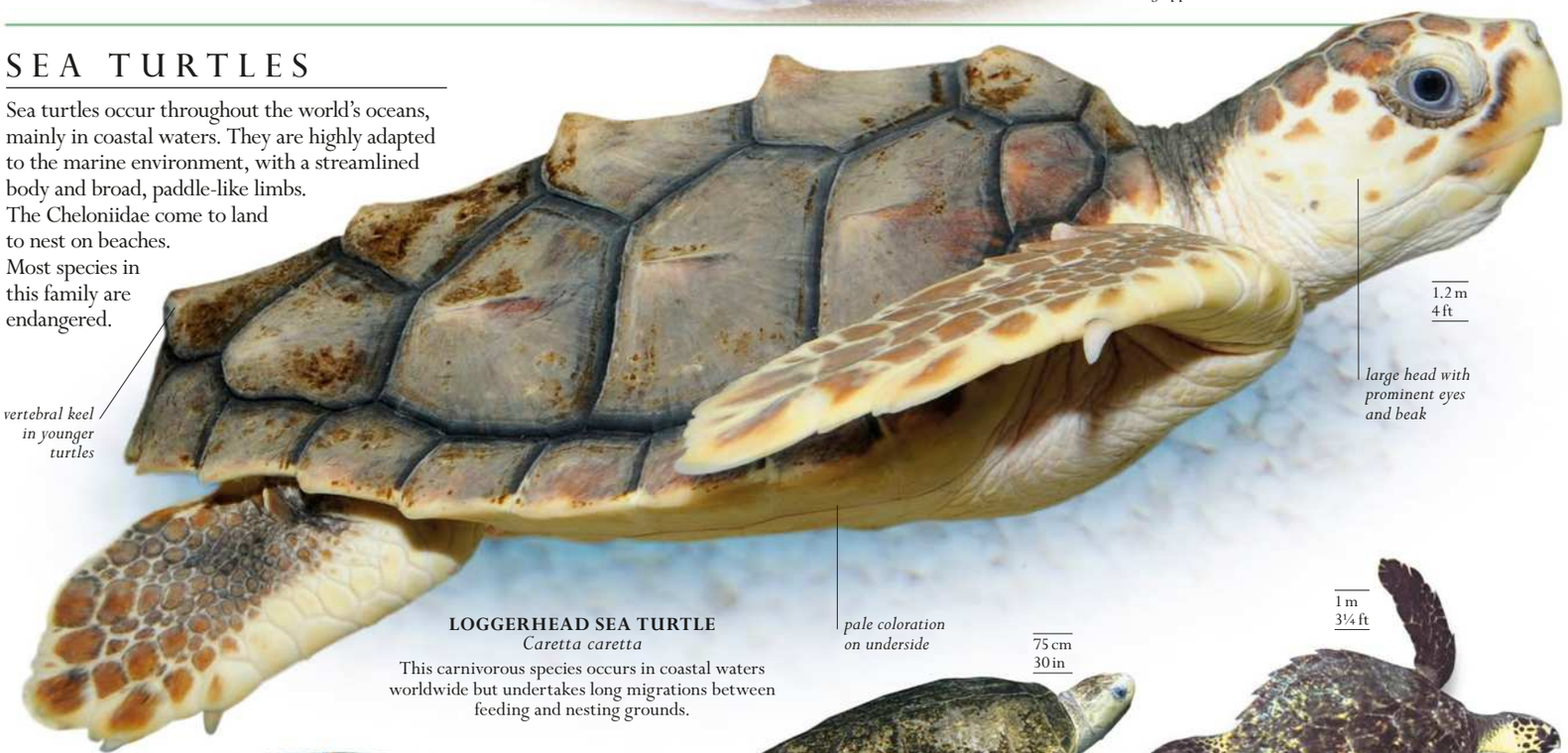
LEATHERBACK SEA TURTLE

There is only one species in the Dermochelyidae. This turtle is capable of maintaining an elevated body temperature, which allows it to swim in cold waters. The shell has no scutes; the leathery skin covers a layer of insulating oily tissue.

LEATHERBACK SEA TURTLE
Dermochelys coriacea
Feeding mainly on jellyfish, this oceanic sea turtle is the world's largest turtle. It has a worldwide distribution that includes subarctic waters.

SEA TURTLES

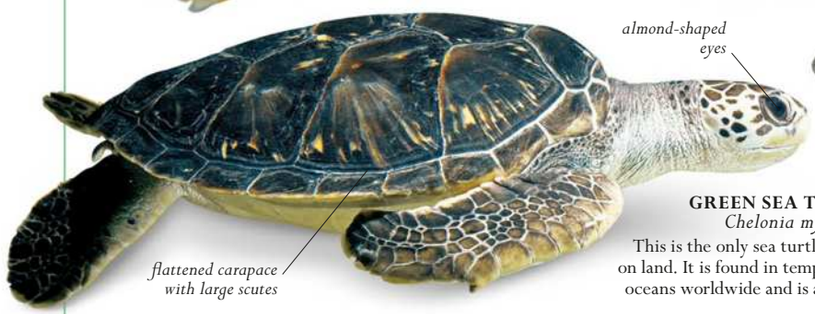
Sea turtles occur throughout the world's oceans, mainly in coastal waters. They are highly adapted to the marine environment, with a streamlined body and broad, paddle-like limbs. The Cheloniidae come to land to nest on beaches. Most species in this family are endangered.



LOGGERHEAD SEA TURTLE
Caretta caretta
This carnivorous species occurs in coastal waters worldwide but undertakes long migrations between feeding and nesting grounds.

OLIVE RIDLEY SEA TURTLE
Lepidochelys olivacea
A species of mainly tropical, shallow coastal waters, this turtle eats a wide range of invertebrates and algae.

HAWKSBILL SEA TURTLE
Eretmochelys imbricata
This turtle uses its horny jaws to forage for molluscs and other prey. It is found in tropical oceans throughout the world.



GREEN SEA TURTLE
Chelonia mydas
This is the only sea turtle known to bask on land. It is found in temperate and tropical oceans worldwide and is a strict herbivore.

POND TURTLES

These turtles range from being fully aquatic to fully terrestrial. Most of them are found in North America, but one species in this family comes from Europe. Diet varies between species, although many are herbivores. The Emydidae are often brightly coloured and intricately marked.

FALSE MAP TURTLE
Graptemys pseudogeographica
This N. American turtle occurs in freshwater habitats with abundant vegetation. Females are almost twice as large as males.

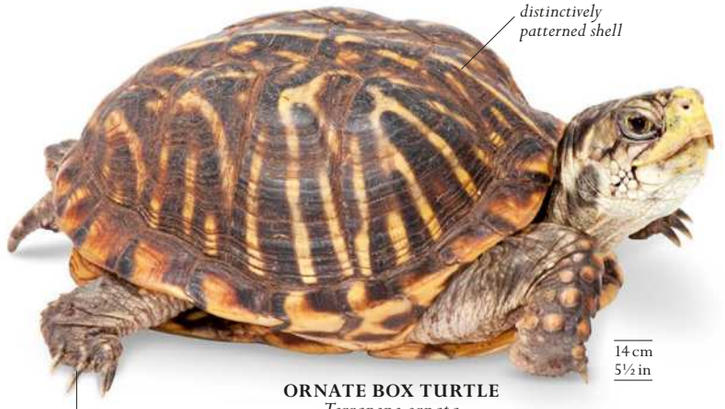
RED-EARED SLIDER
Trachemys scripta elegans
This N. American species is mainly herbivorous and is common in the pet trade. Its ability to colonize new habitats has allowed it to become widely established in Europe and Asia.

YELLOW SLIDER
Trachemys scripta scripta
Named for its habit of sliding into water when disturbed, this turtle of the S. USA is a diurnal omnivore.

DIAMONDBACK TERRAPIN
Malaclemys terrapin
This is a diurnal species of brackish waters in eastern N. America. It has powerful jaws adapted for eating crustaceans and molluscs.

PAINTED TURTLE
Chrysemys picta
Widely distributed in N. America, this small, freshwater turtle is active during summer. During winter, it lies torpid under water.

CAROLINA BOX TURTLE
Terrapene carolina
Males of this N. American species have evolved highly curved claws that help grip the female's domed shell while mating.



ORNATE BOX TURTLE
Terrapene ornata
This is an omnivorous, terrestrial turtle of central N. America. It digs burrows to escape extreme heat or cold.

SPOTTED TURTLE
Clemmys guttata
Identifiable by its spots, this small turtle feeds on aquatic invertebrates and plants in the marshes of eastern N. America.

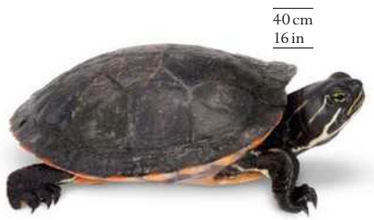
CHICKEN TURTLE
Deirochelys reticularia
This shy turtle of swamps in eastern N. America extends its long neck to strike at crayfish and other prey.

EUROPEAN POND TURTLE
Emys orbicularis
Widespread in Europe, this is a highly aquatic turtle. It basks on logs or rocks, but rapidly dives into the water if disturbed.

WOOD TURTLE
Glyptemys insculpta
This turtle occupies the damp forests in northeastern N. America. Unusually, males and females perform an elegant dance together during courtship.

BLANDING'S TURTLE
Emydoidea blandingii
Found mainly across the Great Lakes region of N. America, this turtle is an omnivore and especially skilled at capturing crayfish.

FLORIDA REDBELLY TURTLE
Pseudemys nelsoni
Restricted to Florida, this turtle lives in lakes and slow-moving streams. During courtship, the male caresses the female's head with his forelimbs.



RED-BELLIED TURTLE
Pseudemys rubriventris
Restricted to the N.E. USA, this omnivorous, diurnal species prefers large, deep bodies of water. Females are larger than males.

ALDABRA GIANT TORTOISE

Aldabrachelys gigantea

The last remaining species of giant tortoise on islands in the Indian Ocean, the Aldabra giant tortoise can weigh over 300 kg (660 lb). Though resident on three islets of the Aldabra atoll, over 90 per cent of the tortoises live on Grande-Terre – the largest islet by far – despite the scarcity of water and inadequate supply of vegetation. Poor conditions there have inhibited the growth of individual tortoises, with many not reaching sexual maturity. However, they are highly sociable, more so than the larger tortoises on other islets. Males are larger than females, but courtship is a gentle affair. Their eggs are buried underground, and hatch in the rainy season. The whole population is vulnerable to natural disasters and rising sea levels.

SIZE 1.2 m (4 ft)
HABITAT Grassy areas
DISTRIBUTION Aldabra, Indian Ocean
DIET Vegetation

^ LEATHERY VISAGE
The skin is tough, leathery, and – depending on islet – either grey or brown. The skin is creased into folds around the neck. If it senses danger, the tortoise pulls its head back inside its shell.

< HORNY BEAK
The tortoise's large mouth contains no teeth. It cuts vegetation with its sharp, horny beak, takes it into the mouth with its tongue, and swallows it whole.

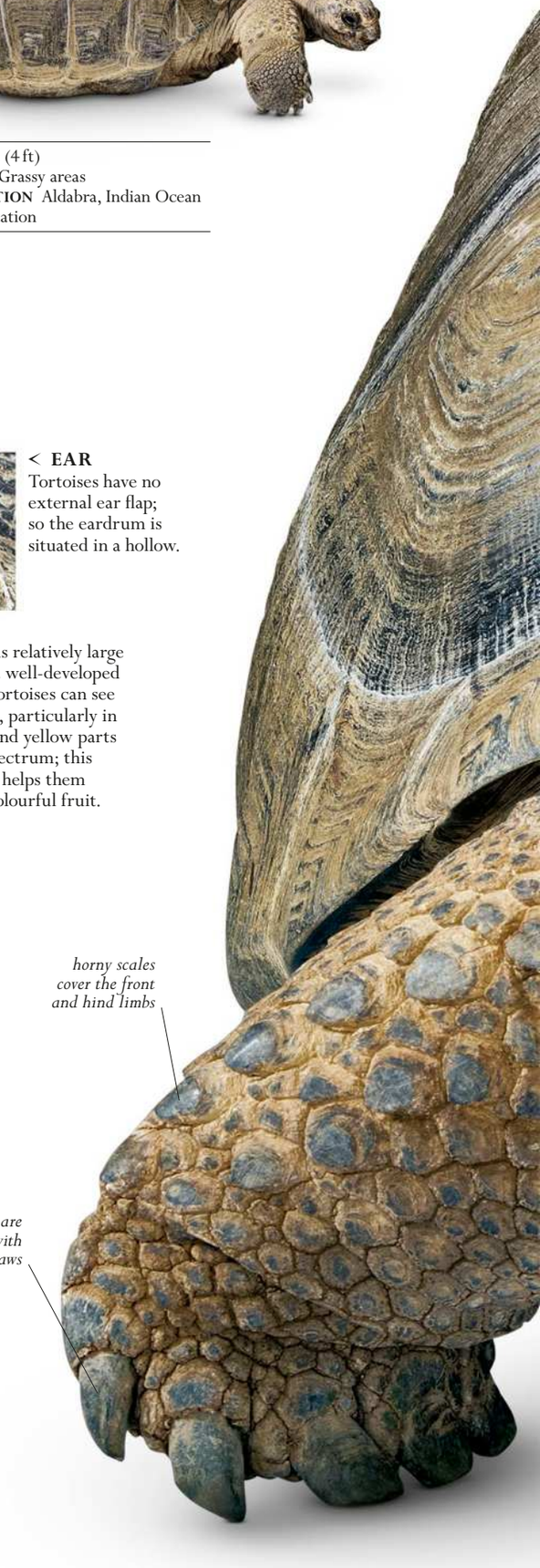
< EAR
Tortoises have no external ear flap; so the eardrum is situated in a hollow.

< EYE
The eye is relatively large and has a well-developed eyelid. Tortoises can see in colour, particularly in the red and yellow parts of the spectrum; this probably helps them to find colourful fruit.

^ FORELEG
The front limbs are cylindrical in shape, and longer than the hind limbs. This allows the tortoise to raise its body well above the ground as it walks. The legs are covered in large, tough scales.

< DIGGING CLAWS
Tortoises have sturdy, elephant-like hind limbs, with five claws on each foot. Females have larger claws than males, which they use when excavating a nesting site.

< TAIL
The giant tortoise has a short tail, and can tuck it to one side under the back of the carapace. Males have longer tails than females.



MADE TO LAST ∨
Compared to giant tortoises from the Galapagos Islands, this species has a more rounded head, a pointed snout, and a smiling mouth. It can live for more than a hundred years.

POND AND RIVER TURTLES

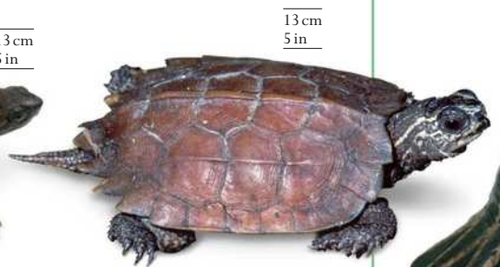
Found both in the Old and New Worlds, the Geoemydidae are freshwater and terrestrial turtles, ranging in adult shell length from 14 to 50 cm (5½–20 in). They vary in their dietary preferences from being herbivorous to carnivorous. Many exhibit sexual dimorphism, with females being larger than males.

BROWN WOOD TURTLE
Rhinoclemmys annulata
A herbivorous tortoise, this species lives in tropical forests of C. America. It is mainly active in the mornings and after rains.

GOLDEN COIN TURTLE
Cuora trifasciata
This is a carnivorous turtle from S. China. Its name derives from its value in the illegal wildlife market. Its use in traditional medicine threatens its survival.

YELLOW-MARGINATED BOX TURTLE
Cuora flavomarginata
An omnivore of China's rice paddies, this species avoids deep water and spends hours basking on land.

ASIAN LEAF TURTLE
Cyclemys dentata
This omnivorous turtle is found in slow-moving waters in S.E. Asia. It defends itself by emitting foul-smelling liquid.



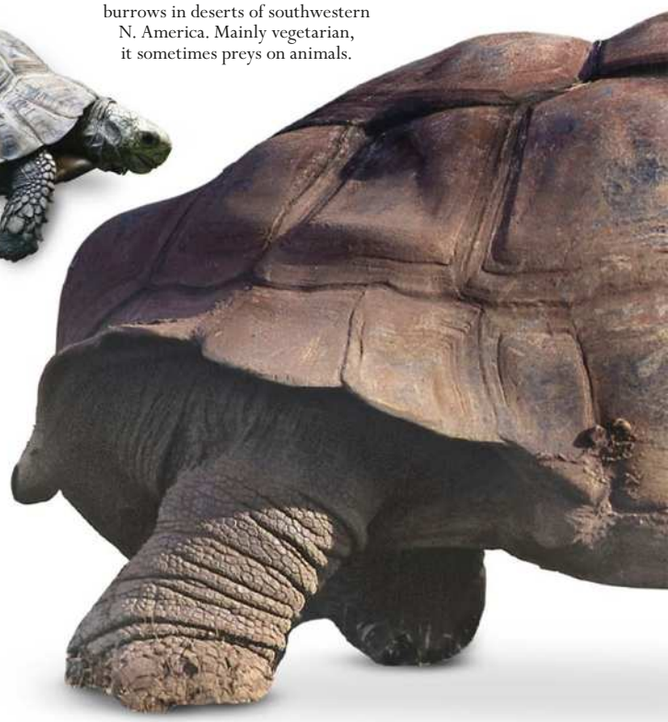
BLACK-BREASTED LEAF TURTLE
Geoemyda spengleri
An inhabitant of wooded mountains in S. China, this turtle eats small invertebrates and fruits. Its carapace is rectangular, keeled, and spiky.

TORTOISES

Found in the Americas, Africa, and southern Eurasia, members of the family Testudinidae can reach great sizes. They have a dome shell into which they can retract their head. Fully terrestrial, tortoises are characterized by elephantine limbs. They lay hard-shelled eggs.

DESERT TORTOISE
Gopherus agassizii
This tortoise lives in small burrows in deserts of southwestern N. America. Mainly vegetarian, it sometimes preys on animals.

ELONGATED TORTOISE
Indotestudo elongata
Found in tropical S.E. Asia, this tortoise eats fruits and carrion. It hides in moist leaf-litter when the weather is dry.



SERRATED HINGE-BACK TORTOISE
Kinixys erosa
This is an omnivorous species found in swamps in tropical W. Africa. Older tortoises develop hinges in the rear of their carapaces.

RED-FOOTED TORTOISE
Chelonoidis carbonaria
Although known to eat carrion, this tortoise is mainly vegetarian. It is found in a variety of habitats of northeastern S. America.

RADIATED TORTOISE
Astrochelys radiata
Restricted to S. Madagascar, this endangered species eats mainly plants and is active during the early part of the day.

INDIAN STAR TORTOISE
Geochelone elegans
Found in dry areas of India and Sri Lanka, this herbivorous species mates and breeds in the monsoon season.

PANCAKE TORTOISE
Malacochersus tornieri
Found in E. Africa, this omnivorous species inhabits rocky areas. Its flat shape allows it to hide in cracks.

GALAPAGOS TORTOISE
Chelonoidis nigra
One of the world's largest tortoises, this mainly vegetarian species has 11 subspecies, from different islands in the Galapagos archipelago.

ALDABRA GIANT TORTOISE
Aldabrachelys gigantea
Restricted to the Aldabra atoll in the Indian Ocean, this large herbivore is able to drink through its nostrils.

HERMANN'S TORTOISE
Testudo hermanni
This herbivorous species inhabits dry forests of coastal Italy and S. France. It hibernates during the cold winter months.

STEPPES TORTOISE
Agrionemys horsfieldii
A herbivore from the dry deserts and steppes of C. Asia, this species escapes the daytime heat by sheltering in burrows.

TUATARA

Superficially like a lizard, New Zealand's tuatara belongs to a far more ancient order of reptiles. Its closest relatives became extinct 100 million years ago.

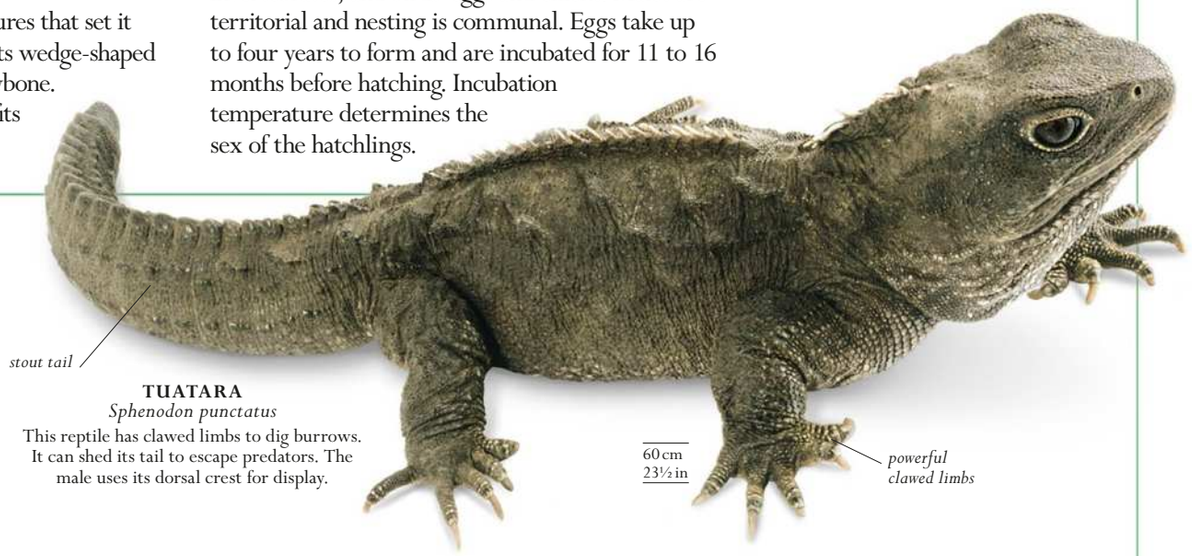
The tuatara has many anatomical features that set it apart from lizards. Most striking are its wedge-shaped "teeth" – actually serrations of the jawbone. The upper jaw has a double row that fits over a single row on the lower jaw.

Tuataras are very long lived, but are vulnerable to introduced ground predators. Inhabiting coastal forests, they are active at low body temperatures and emerge from their burrows at night to hunt for invertebrates, and birds' eggs and chicks. Males are territorial and nesting is communal. Eggs take up to four years to form and are incubated for 11 to 16 months before hatching. Incubation temperature determines the sex of the hatchlings.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	RHYNCHOCEPHALIA
FAMILIES	1
SPECIES	1

TUATARA

Often portrayed as "living fossils", the Sphenodontidae are modern representatives of reptiles that coexisted with dinosaurs. This primitive species is found only on offshore islands of New Zealand.



TUATARA
Sphenodon punctatus
This reptile has clawed limbs to dig burrows. It can shed its tail to escape predators. The male uses its dorsal crest for display.

LIZARDS

Typically, lizards have four legs and a long, thin tail, but there are also many legless species. They have scaly skin and firm jaw articulation.

All lizards are ectothermic, obtaining heat energy from the environment. Although seen as predominately tropical or desert animals, they have a global distribution; lizards are found from beyond the Arctic Circle in Europe to the tip of South America. Highly adaptable, they occupy a wide range of terrestrial habitats with many being arboreal or rock-dwelling. Many legless species are adapted for burrowing, a few lizards are effective gliders from trees, and others are semi-aquatic, including a marine species on the Galapagos Islands.

STRATEGIES FOR SURVIVAL

Lizards range in length from about 1.5 cm (½ in) to 3 m (10 ft) in the case of the Komodo dragon, but the majority are between 10 and 30 cm (4–12 in). Although most are carnivores, around two per cent of species are primarily herbivorous. Many lizards are prey for other carnivores. Their defence mechanisms depend on agility, camouflage, and bluff. Many species are able to shed their tail to distract the attention of predators as they escape. The tail grows back. In some families of lizard, the skin can change colour. This ability can be used for camouflage or for sexual or social signalling. Unusually, in many lizards the pineal gland on the top of the head acts as a light-sensitive "third eye".

VARIED LIFESTYLES

Although some species are solitary, many lizards have complex social structures, with the males maintaining their territories through visual signals. Many species lay eggs in underground nests, while others retain the eggs in the oviduct until hatching. There are also truly viviparous species, in which the mother provides nutrition via a placenta. Males have paired hemipenes – sexual organs used for internal fertilization – although some species are parthenogenetic, with females reproducing without the participation of a male. Some lizards tend their eggs during incubation but very few exhibit any maternal care of the hatchlings.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (LIZARDS)	38
SPECIES	6,687

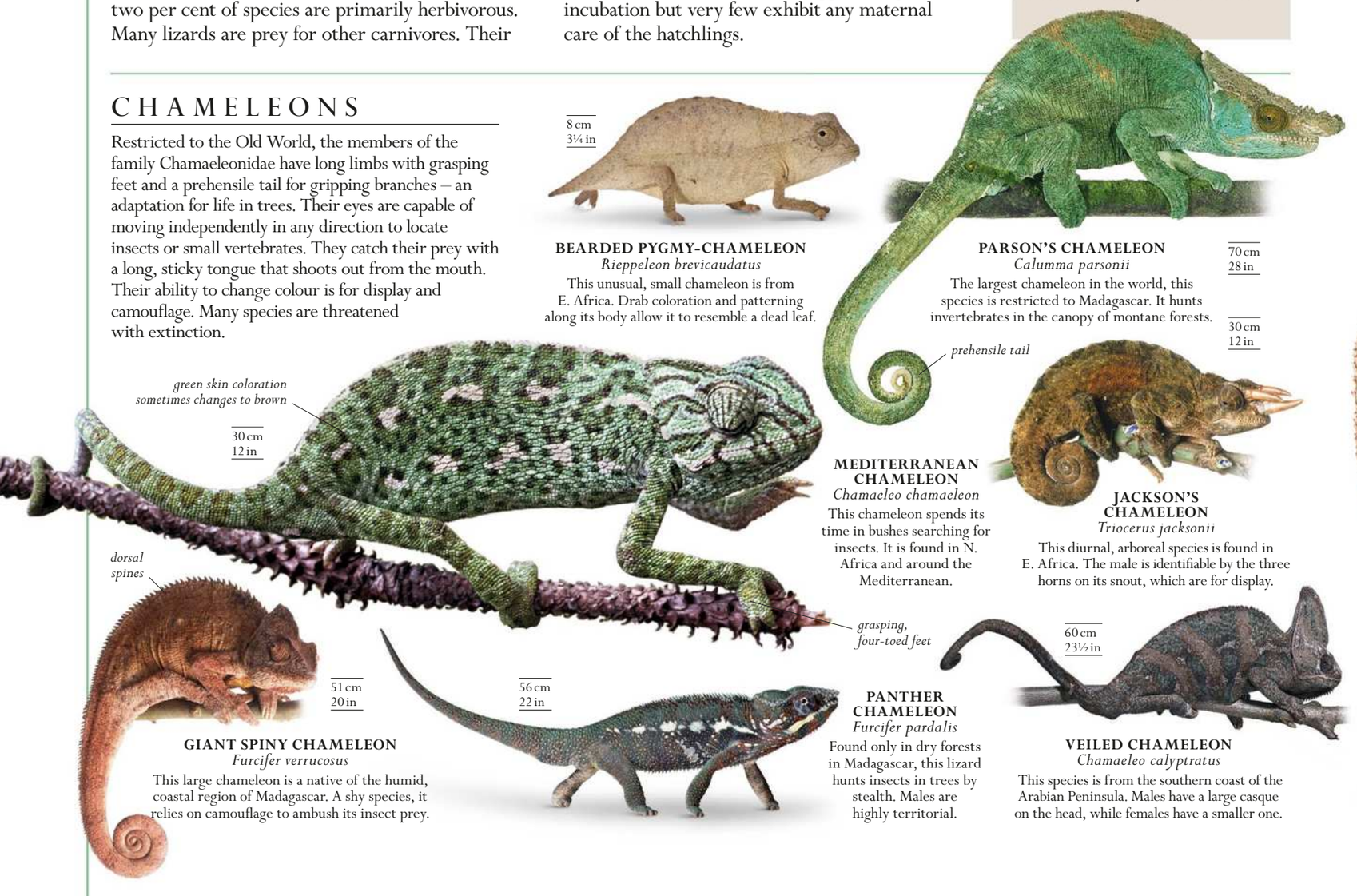
DEBATE

SQUAMATA: AN ALL-INCLUSIVE ORDER

Traditionally, lizards and snakes were considered two distinct groups, but modern genetic research makes it clear that they are not. Primitive squamates (scaled reptiles) were lizard-like animals that arose in the mid-Jurassic. Available evidence suggests that snakes evolved from lizards during the mid-Cretaceous. By this time various families of lizards had branched off on their own evolutionary course. Some lizard families are thus closer to snakes than they are to other lizards. Of living lizards, the monitors are thought to be those most closely related to snakes.

CHAMELEONS

Restricted to the Old World, the members of the family Chamaeleonidae have long limbs with grasping feet and a prehensile tail for gripping branches – an adaptation for life in trees. Their eyes are capable of moving independently in any direction to locate insects or small vertebrates. They catch their prey with a long, sticky tongue that shoots out from the mouth. Their ability to change colour is for display and camouflage. Many species are threatened with extinction.



BEARDED PYGMY-CHAMELEON
Rieppeleon brevicaudatus
This unusual, small chameleon is from E. Africa. Drab coloration and patterning along its body allow it to resemble a dead leaf.

PARSON'S CHAMELEON
Calumma parsonii
The largest chameleon in the world, this species is restricted to Madagascar. It hunts invertebrates in the canopy of montane forests.

MEDITERRANEAN CHAMELEON
Chamaeleo chamaeleon
This chameleon spends its time in bushes searching for insects. It is found in N. Africa and around the Mediterranean.

JACKSON'S CHAMELEON
Triocerus jacksonii
This diurnal, arboreal species is found in E. Africa. The male is identifiable by the three horns on its snout, which are for display.

GIANT SPINY CHAMELEON
Furcifer verrucosus
This large chameleon is a native of the humid, coastal region of Madagascar. A shy species, it relies on camouflage to ambush its insect prey.

PANTHER CHAMELEON
Furcifer pardalis
Found only in dry forests in Madagascar, this lizard hunts insects in trees by stealth. Males are highly territorial.

VEILED CHAMELEON
Chamaeleo calyptratus
This species is from the southern coast of the Arabian Peninsula. Males have a large casque on the head, while females have a smaller one.

CHISEL-TEETH LIZARDS

Common in Africa, southern Asia, and Australasia, the small lizards of the family Agamidae – which also includes flying lizards and water dragons – are the Old World equivalents of the iguanas. Spines, flaps, and crests often adorn the head and back of these lizards, which lay soft-shelled eggs. Males are brightly coloured while the females are duller.

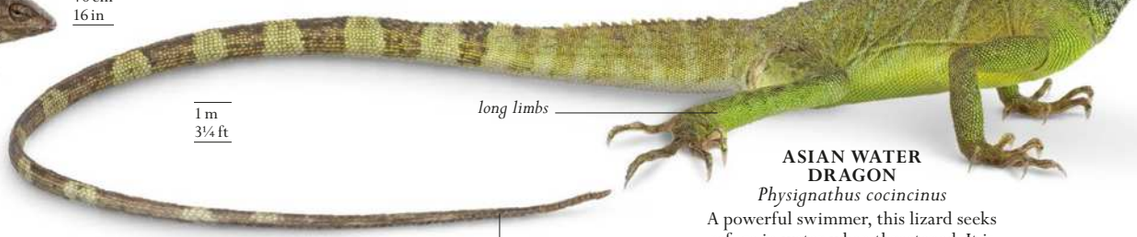
1 m
3¼ ft

AUSTRALIAN WATER DRAGON
Intellagama lesueurii
The largest water dragon in Australia, this species lives beside water into which it dives to escape predators. Adults eat invertebrates and small vertebrates.

40 cm
16 in

ORIENTAL GARDEN LIZARD
Calotes versicolor
This agile, diurnal lizard is often found hunting insects in trees around human habitation. It is common in S. Asia.

long tail helps with balance when climbing



1 m
3¼ ft

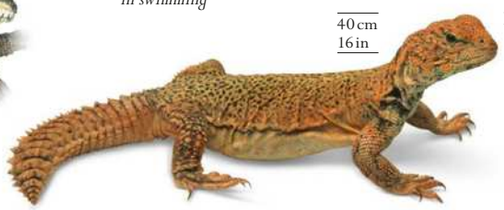
long limbs

long, laterally flattened tail used in swimming

ASIAN WATER DRAGON
Physignathus cocincinus
A powerful swimmer, this lizard seeks refuge in water when threatened. It is found in riverside trees in S. Asia.

26 cm
10 in

BOULENGER'S PRICKLENAPE
Acanthosaura crucigera
This slow-moving lizard from Asia preys on insects while perched on a branch. Males use the long spines on their neck when fighting each other.



40 cm
16 in

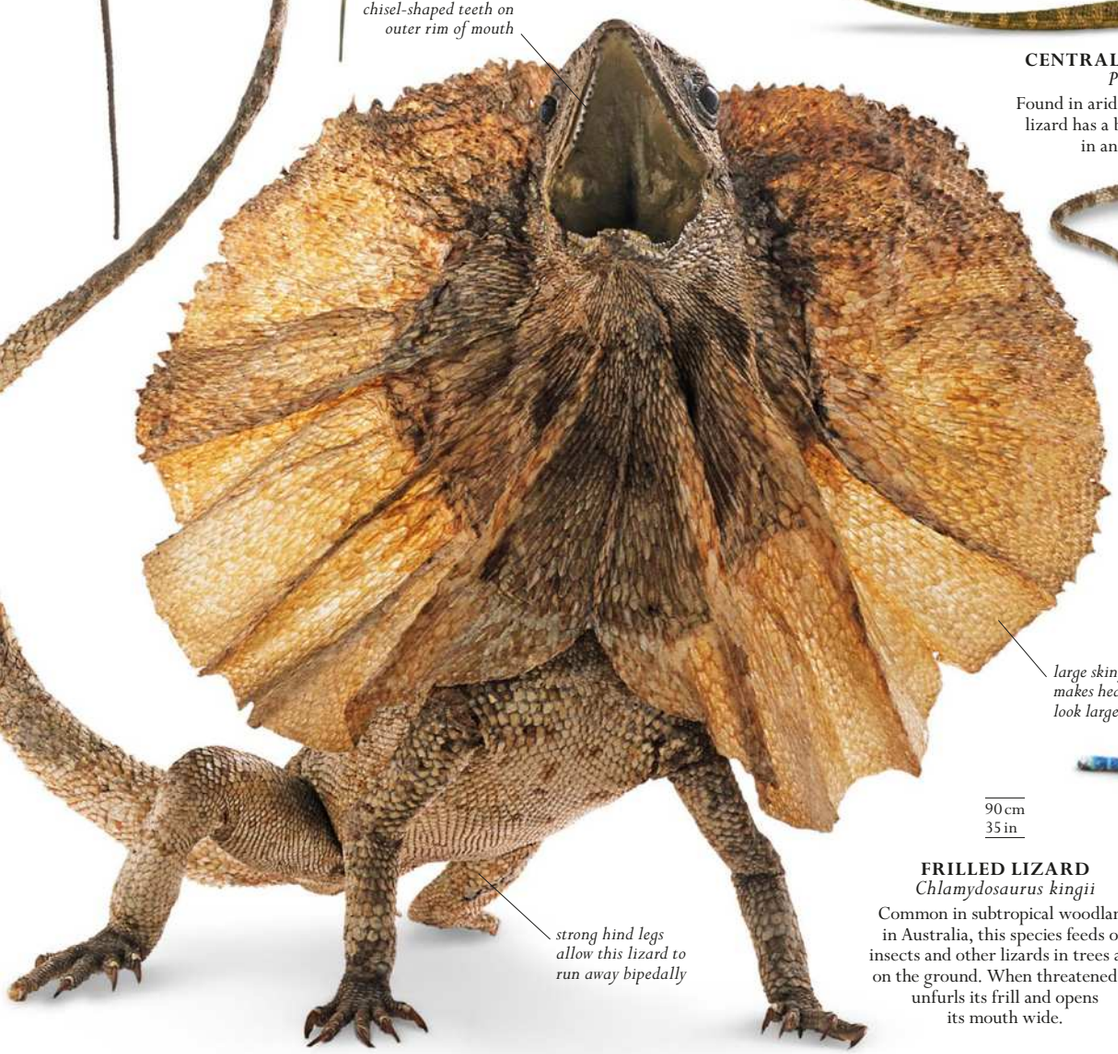
NORTH AFRICAN MASTIGURA
Uromastyx acanthinura
This herbivorous lizard inhabits the harsh desert environments of N. Africa. It uses its club-like, spiny tail in defence.

CENTRAL BEARDED DRAGON
Pogona vitticeps
Found in arid woodland in Australia, this lizard has a beard of spines. It lays eggs in an underground nest.

50 cm
20 in

20 cm
8 in

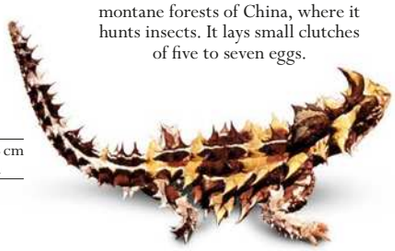
GREEN-STRIPED TREE DRAGON
Diploderma splendidum
This colourful lizard is from humid montane forests of China, where it hunts insects. It lays small clutches of five to seven eggs.



chisel-shaped teeth on outer rim of mouth

large skin frill makes head look larger

strong hind legs allow this lizard to run away bipedally



15–18 cm
5–7 in

THORNY DEVIL
Moloch horridus
This Australian lizard feeds exclusively on ants. The body is covered with large, thorny spines, which make it difficult for a predator to swallow. The spines also channel rainwater or morning dew into its mouth.

90 cm
35 in

FRILLED LIZARD
Chlamydosaurus kingii
Common in subtropical woodland in Australia, this species feeds on insects and other lizards in trees and on the ground. When threatened, it unfurls its frill and opens its mouth wide.

40 cm
16 in

RAINBOW LIZARD
Agama agama
This common, insectivorous lizard from Africa is grey at night, but becomes brightly coloured in sunlight. Males use their bright skin colours during territorial disputes.

PANTHER CHAMELEON
Furcifer pardalis

This large chameleon is endemic to Madagascar off the east coast of southern Africa, and has also been introduced to Mauritius and Réunion. This species lives in trees in humid scrubland, and its feet are so well adapted for grasping branches that it is difficult for the lizard to walk across a flat surface. Active during the day, it moves slowly through the branches to hunt its insect food by stealth. When it spots its next meal, the chameleon focuses on its victim with both eyes, then shoots out its long tongue to grasp the insect and pull it back into its large mouth. The chameleon's uncanny ability to change colour is an indicator of mood and social status only, and is not used for camouflage. When faced with a rival, it rapidly inflates its body and changes colour, putting on a display of dominance that is usually enough to decide a dispute.

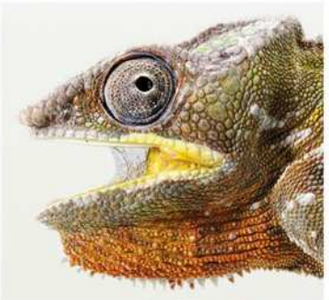
SIZE 40–56 cm (16–22 in)
HABITAT Trees in humid scrub
DISTRIBUTION Madagascar
DIET Arthropods, crustaceans

a ridge of protective spines runs along the midline of the back

casque, or bony shield, at the back of the head

EYES >
Uniquely, chameleons are able to move each eye independently of the other. With eyes pointing in different directions, the chameleon can look out for predators while also searching for prey. Chameleons do not have ears.

< TONGUE
The tongue is very long and is fired from the mouth at great speed. This means that the chameleon can seize unsuspecting prey from some distance away.



∨ SKIN COLOUR
The striking skin colours are caused by cells called chromatophores, which contain a variety of pigments and reflectors. The cells' size and dispersion of pigments change with the chameleon's mood, often quickly and dramatically, as a signal to potential rivals and mates.

the muscular tongue and its mucus envelop the prey, pulling it to the mouth

insect prey

robust scales protrude from the snout to form a small horn

wide jaw

sharp spines run from the mouth along the underside of the chin

∨ CLAWED FEET
The chameleon's toes are clawed, and arranged into groups of two and three on opposite sides of the foot. This enables the animal to grip any branch tightly.

TAIL >
Life up in the trees is made a lot easier by the chameleon's prehensile tail. It acts as a fifth limb, wrapping around branches to help with climbing.

∨ UNDERSIDE
This chameleon was photographed through a glass table from below. They rarely, if ever, have to walk on flat ground; when they do, their feet are splayed.

ridge of spines

long tail

splayed foot

GECKOS

Widely distributed in the tropics and subtropics, the superfamily Gekkonidae number over 1,000 species in 100 genera. They are noted for being very vocal and for their ability to climb smooth surfaces. Many lay hard-shelled eggs, while others lay soft-shelled eggs. Some species are viviparous.

12 cm
4¾ in

WESTERN BANDED GECKO
Coleonyx variegatus
This terrestrial gecko hunts invertebrates in the deserts of the W. USA. Unlike many geckos, it has moveable eyelids.

25 cm
10 in

AFRICAN FAT-TAILED GECKO
Hemitheconyx caudicinctus
Common in the W. Sahara, this species has a tail that stores fat. It lacks the adhesive foot pads of many other geckos.

21 cm
8½ in

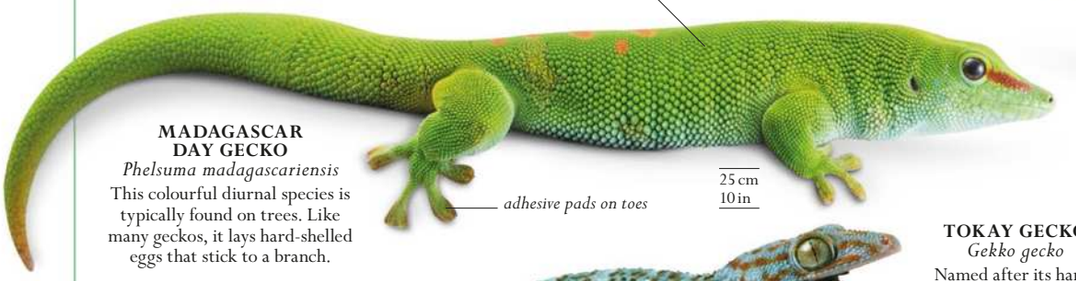
COMMON LEOPARD GECKO
Eublepharis macularius
Originally from southern C. Asia, this gecko is a popular pet, which has been bred for different markings and colours.

15 cm
6 in

MOORISH GECKO
Tarentola mauritanica
Common around the Mediterranean, this agile gecko preys on insects. It lives on rock faces but often enters houses.

20 cm
8 in

WONDER GECKO
Teratoscincus scincus
To defend itself, this C. Asian species waves its tail slowly, causing a row of large scales on the tail to rub together, making a hissing sound.



25 cm
10 in

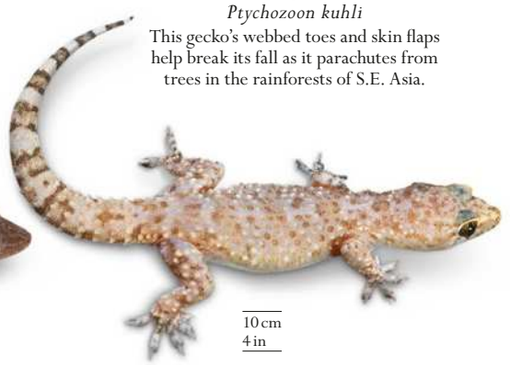
MADAGASCAR DAY GECKO
Phelsuma madagascariensis
This colourful diurnal species is typically found on trees. Like many geckos, it lays hard-shelled eggs that stick to a branch.

20 cm
8 in

KUHL'S FLYING GECKO
Ptychozoon kuhli
This gecko's webbed toes and skin flaps help break its fall as it parachutes from trees in the rainforests of S.E. Asia.

40 cm
16 in

TOKAY GECKO
Gekko gecko
Named after its harsh "to-kay" call, this large gecko from S.E. Asia often lives in houses.



10 cm
4 in

MEDITERRANEAN GECKO
Hemidactylus turcicus
Often betrayed by its mewing cry, this small European gecko is common in houses, where it hunts insects attracted to lights.

34 cm
13½ in

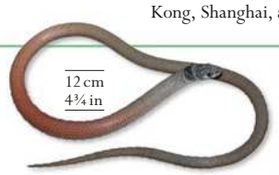
RING-TAILED GECKO
Cyrtodactylus louisiadensis
Found in New Guinea, this large, nocturnal gecko feeds aggressively on invertebrates and small frogs found on the ground.

15 cm
6 in

BROOK'S HOUSE GECKO
Hemidactylus brookii
This gecko lives in close proximity to humans. Native to N. India, it now also occurs in Hong Kong, Shanghai, and the Philippines.

FLAP-FOOTED LIZARDS

All lizards of this group have an elongated body, no front limbs, and much-reduced hind limbs. Restricted to Australasia, the 36 species in the family Pygopodidae hunt insects by burrowing or on the surface. They are related to geckos and lay soft-shelled eggs.



12 cm
4¾ in

FRASER'S DELMA
Delma fraseri
This insectivorous, Australian lizard inhabits spinifex grassland. It is well adapted to moving through the stiff blades of grass.

21 cm
8½ in

COMMON SCALY FOOT
Pygopus lepidopodus
Snake-like in appearance, this lizard is widespread in Australia. It is a diurnal predator of insects and tunnel-inhabiting spiders.

60 cm
23½ in

BURTON'S SNAKE-LIZARD
Lialis burtonis
Native to Australia, this lizard has an elongated, wedge-shaped snout that it uses to grasp skinks, which it consumes whole.

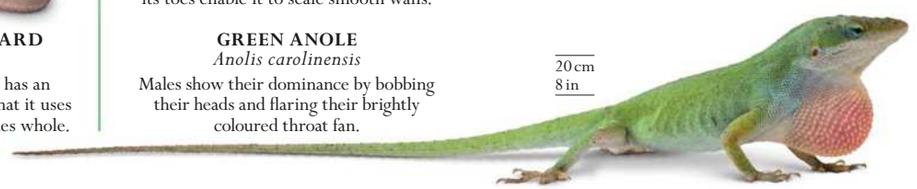
ANOLES

Most anoles come from around the Caribbean. A diverse group, the Dactyloidae are typically small, arboreal, and insectivorous. Although often green or brown, they change skin colour according to mood and environment. Both sexes aggressively defend their territories.

50 cm
20 in

KNIGHT ANOLE
Anolis equestris
The largest anole, this species is restricted to Cuba. Adhesive pads on its toes enable it to scale smooth walls.

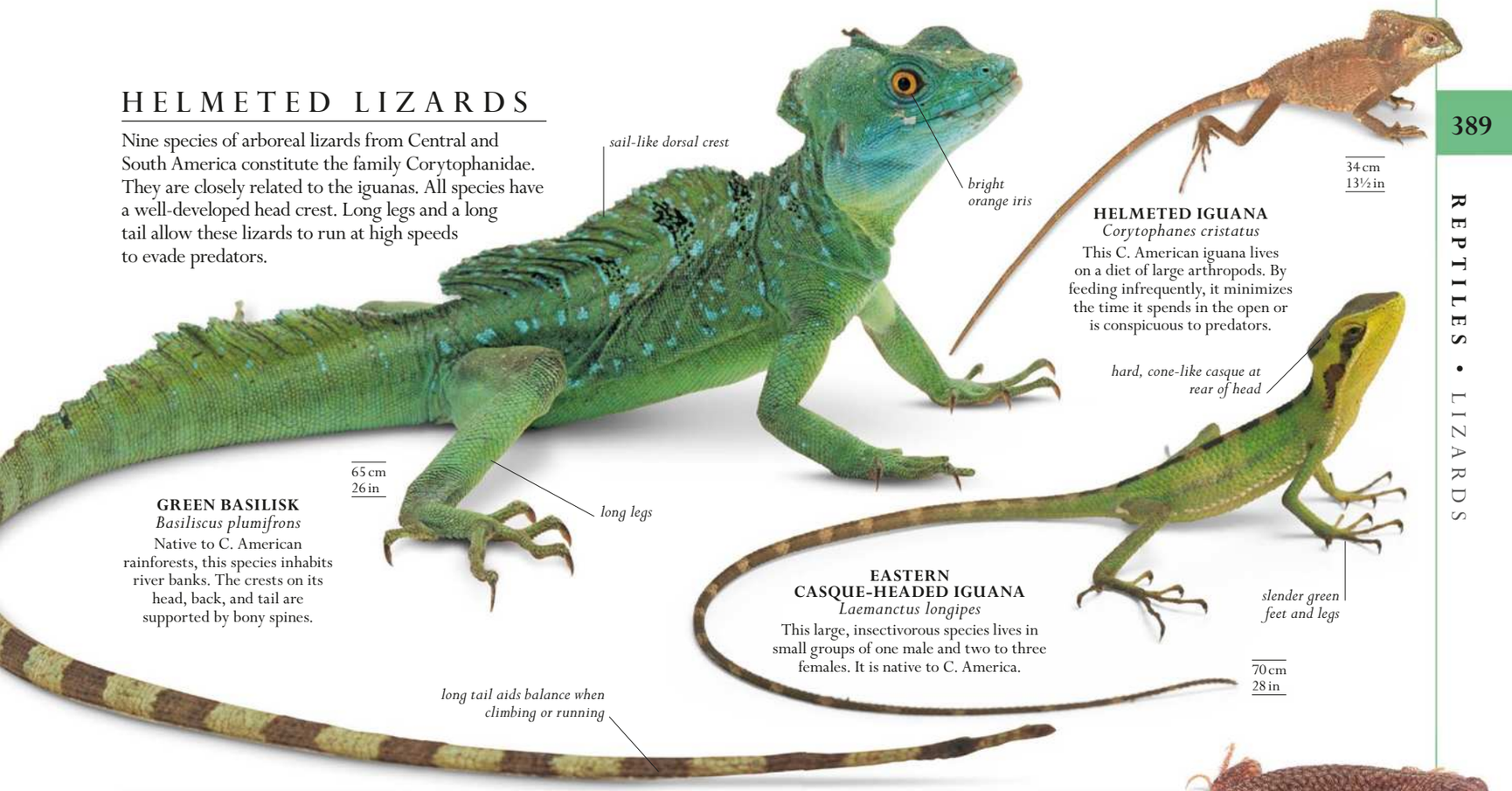
GREEN ANOLE
Anolis carolinensis
Males show their dominance by bobbing their heads and flaring their brightly coloured throat fan.



20 cm
8 in

HELMETED LIZARDS

Nine species of arboreal lizards from Central and South America constitute the family Corytophanidae. They are closely related to the iguanas. All species have a well-developed head crest. Long legs and a long tail allow these lizards to run at high speeds to evade predators.



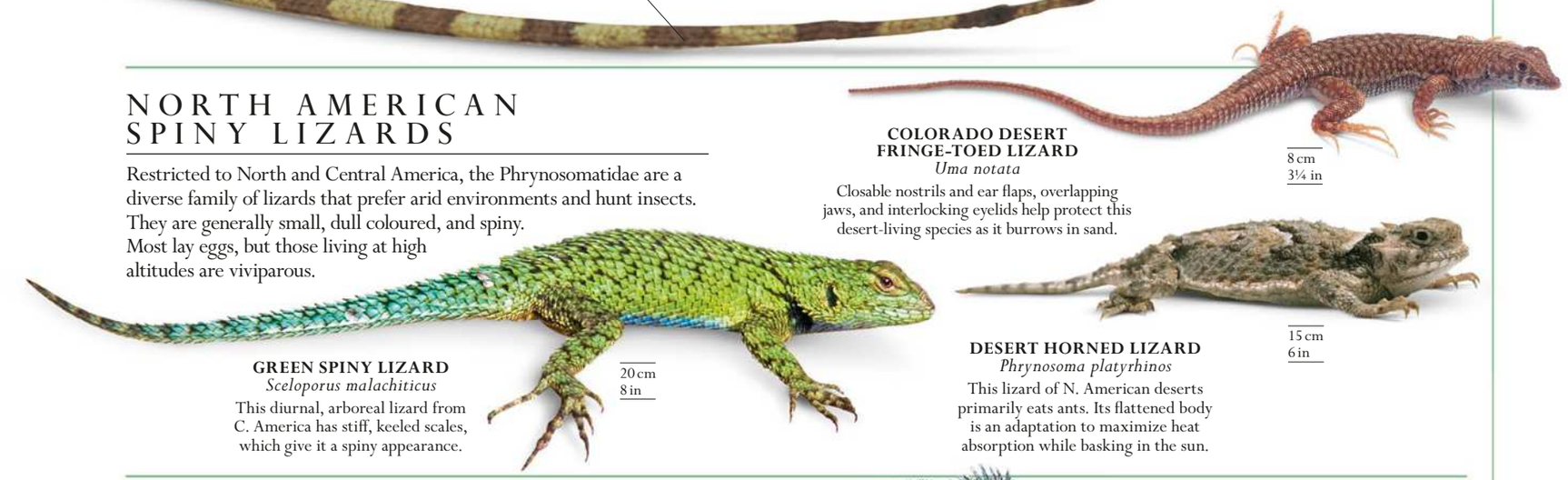
GREEN BASILISK
Basiliscus plumifrons
Native to C. American rainforests, this species inhabits river banks. The crests on its head, back, and tail are supported by bony spines.

HELMETED IGUANA
Corytophanes cristatus
This C. American iguana lives on a diet of large arthropods. By feeding infrequently, it minimizes the time it spends in the open or is conspicuous to predators.

EASTERN CASQUE-HEADED IGUANA
Laemanctus longipes
This large, insectivorous species lives in small groups of one male and two to three females. It is native to C. America.

NORTH AMERICAN SPINY LIZARDS

Restricted to North and Central America, the Phrynosomatidae are a diverse family of lizards that prefer arid environments and hunt insects. They are generally small, dull coloured, and spiny. Most lay eggs, but those living at high altitudes are viviparous.



COLORADO DESERT FRINGE-TOED LIZARD
Uma notata
Closable nostrils and ear flaps, overlapping jaws, and interlocking eyelids help protect this desert-living species as it burrows in sand.

GREEN SPINY LIZARD
Sceloporus malachiticus
This diurnal, arboreal lizard from C. America has stiff, keeled scales, which give it a spiny appearance.

DESERT HORNED LIZARD
Phrynosoma platyrhinos
This lizard of N. American deserts primarily eats ants. Its flattened body is an adaptation to maximize heat absorption while basking in the sun.

IGUANAS

Largely confined to the Americas, the Iguanidae number nearly 30 species in 8 genera. They are diverse in colour. Most are diurnal, carnivorous predators, although larger species are herbivorous. They all lay eggs.

MARINE IGUANA
Amblyrhynchus cristatus
Native to the Galapagos Islands, this aquatic lizard is well adapted to feeding on underwater algae. Nasal glands help remove salt.

GREEN IGUANA
Iguana iguana
Widespread in C. and S. America, this large iguana is herbivorous. Males defend their territory by vigorously nodding their heads to display dominance.

BLACK IGUANA
Ctenosaura similis
This gregarious species from C. America lives in colonies with a dominant male. Although usually herbivorous, it sometimes eats small lizards.

SKINKS

Distributed worldwide, the Scincidae are a diverse group of 1,400 species. While many are active diurnal predators, several others are nocturnal, limbless, burrowing lizards. They use chemical as well as visual communication. Although typically oviparous, many species are viviparous.

FIRE SKINK
Mochlus fernandi
This insectivorous skink is native to humid, forested areas of W. Africa. Its attractive coloration makes it a popular lizard to keep in captivity.

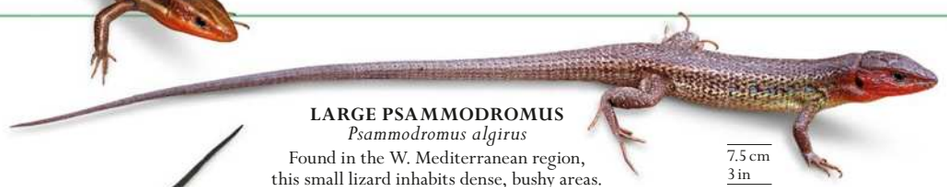
EMERALD TREE SKINK
Lamprolepis smaragdina
Native to islands of the W. Pacific, this arboreal lizard preys on insects on bare tree trunks.

FIVE-LINED SKINK
Plestiodon fasciatus
This N. American skink coils around its eggs to protect them during incubation. It prefers woodland and feeds on ground-living insects.

PERCIVAL'S LANCE SKINK
Acontias percivali
This legless African skink burrows through leaf litter to hunt its invertebrate prey. It gives birth to up to three live young.

WALL AND SAND LIZARDS

Lizards of the family Lacertidae are found in a wide variety of habitats throughout the Old World. They are active predators and have complex social systems, with males defending their territory. Almost all species lay eggs. These lizards typically have a large head.



LARGE PSAMMODROMUS
Psammodromus algirus
Found in the W. Mediterranean region, this small lizard inhabits dense, bushy areas. During breeding, males develop a red patch on their throat.

OCELLATED LIZARD
Timon lepidus
The largest European member of the family, this lizard lives in dry, bushy places. It eats insects, eggs, and small mammals.

VIVIPAROUS LIZARD
Zootoca vivipara
Found throughout Europe and up to 3,000 m (9,900 ft) in the Alps, this ground-dwelling lizard lives in a variety of habitats. It gives birth to live young.

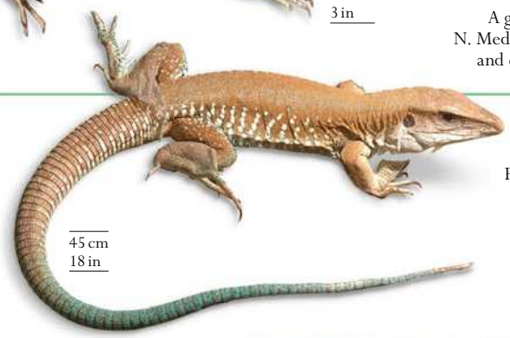
FRINGE-TOED LIZARD
Acanthodactylus erythrurus
Found in the Iberian Peninsula and N. Africa, this species has fringes of spiny scales on its toes that enable it to cross over loose sand.

ITALIAN WALL LIZARD
Podarcis siculus
A ground-living species, found around the N. Mediterranean, this lizard inhabits grassy places and often lives in close proximity to humans.

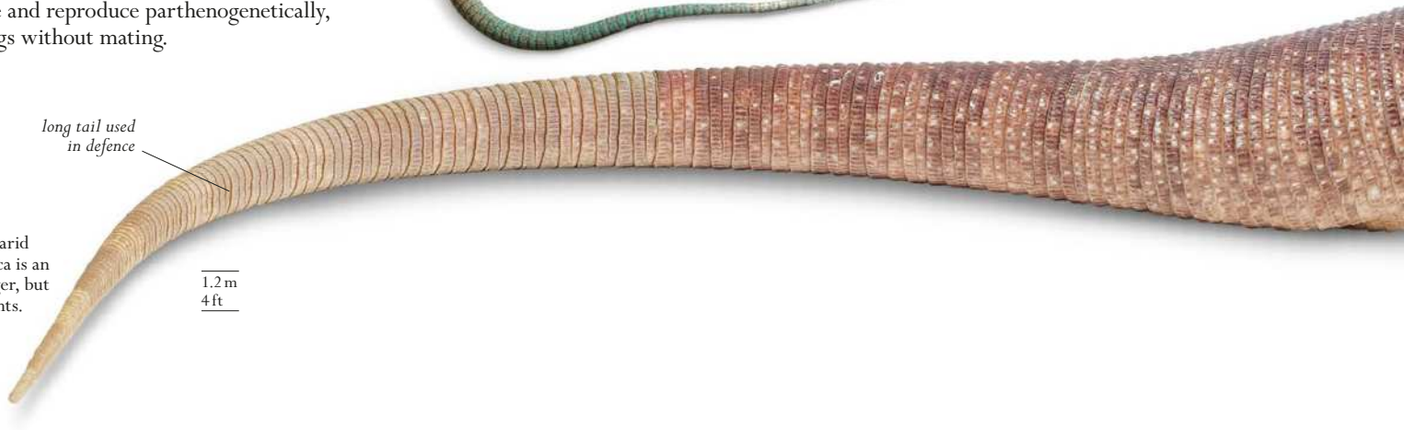
GRAN CANARIA GIANT LIZARD
Gallotia stehlini
This large species is restricted to the shrubland of Grand Canary Island. It is diurnal and herbivorous.

WHIPTAILS AND RACERUNNERS

These fast-running American lizards occupy a range of habitats. Smaller species of the Teiidae are insectivorous but larger ones are carnivorous. All 120 species are oviparous, although many whiptails are all-female and reproduce parthenogenetically, laying viable, fertile eggs without mating.



AMAZON RACERUNNER
Ameiva ameiva
Powerful jaws allow this S. American species to feed on small vertebrates and insects that it catches in open terrestrial habitats.



RED TEGU
Salvator rufescens
This large species of the arid regions in central S. America is an active predator and scavenger, but is also known to eat plants.

BERBER SKINK
Eumeces schneideri
This diurnal skink eats insects, small vertebrates, and carrion. It is native to N. Africa and the deserts of S.W. Asia.

40 cm
16 in

72 cm
28 in

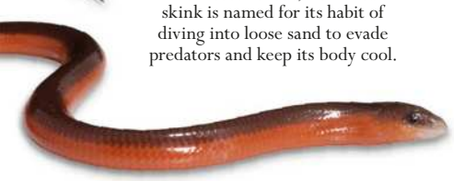
EASTERN BLUE-TONGUED SKINK
Tiliqua scincoides
Characterized by its eponymous blue tongue, this Australian skink is a diurnal omnivore. It bears live young.

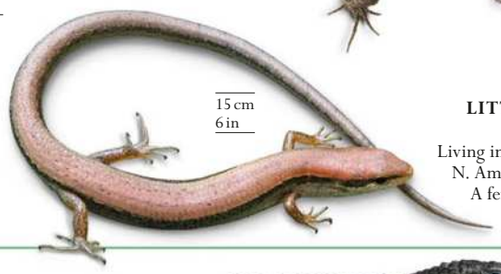
MANY-LINED SUN SKINK
Eutropis multifasciata
Found in S. Asia, this lizard hunts insects in sunlit clearings within forests. It gives birth to live young.

35 cm
14 in

20 cm
8 in

SANDFISH SKINK
Scincus scincus
This insectivorous, N. African skink is named for its habit of diving into loose sand to evade predators and keep its body cool.





15 cm
6 in

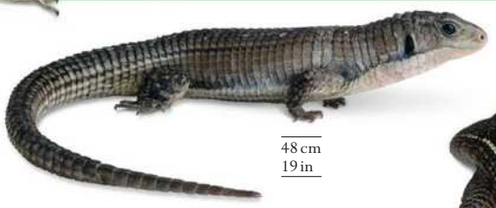
LITTLE BROWN SKINK
Scincella lateralis
Living in leaf litter in woodland, this N. American skink hunts insects. A female can store sperm to fertilize her eggs.

37 cm
14½ in

SOLOMON ISLANDS SKINK
Corucia zebrata
This is the world's largest skink. It is strictly arboreal, has a prehensile tail, and is herbivorous. It lives in groups.

PLATED LIZARDS

There are 32 species of plated lizards. All are from sub-Saharan Africa and lay eggs. They have a cylindrical body with well-developed legs for hunting insects in rocky areas and the savanna. Solitary in nature, the Gerrhosauridae are often aggressive to other members of their species.



48 cm
19 in

ROUGH-SCALED PLATED LIZARD
Broadleysaurus major
This omnivorous species is widely distributed in the savanna of E. Africa. It occupies crevices in rocky outcrops or termite nests.

36 cm
14 in

MADAGASCAN GIRDLED LIZARD
Zonosaurus madagascariensis
This insectivorous lizard is native to Madagascar. It prefers to be solitary, and feeds on the ground in open, dry habitats.

GIRDLED LIZARDS

Limited to southern and eastern Africa, the Cordylidae are named for the rings of spiny scales that encircle their tail. Their flattened body has limited space for live young or eggs. In viviparous species, this restricts litter size; oviparous species lay only two eggs.

CAPE GIRDLED LIZARD
Cordylus cordylus
Endemic to southern Africa, this lizard lives in dense colonies. Adults are aggressive, and form social hierarchies under a dominant male.

21 cm
8½ in

MICROTEIID LIZARDS

There are 165 species of the Gymnophthalmidae in tropical South America. Generally small, they are characterized by large scales on their back. These are diurnal and secretive insectivorous lizards and their dull coloration provides camouflage in leaf litter. Most species lay eggs.

BROMELIAD LIZARD
Anadia ocellata
An arboreal species found in C. America, the bromeliad lizard hunts insects and takes refuge in foliage.

8 cm
3¼ in

CROCODILE LIZARD

The crocodile lizard is the only representative of the Shinisauridae. There are two recognized sub-species found in China and northern Vietnam. This little-studied lizard is endangered because of the popularity of the lizards as pets.

CHINESE CROCODILE LIZARD
Shinisaurus crocodilurus crocodilurus
Restricted to the Guangxi region of S. China, this aquatic lizard feeds on fish and tadpoles. It basks on riverside bushes.

XENOSAURS

Found mainly in Mexico, these unusual lizards have the top of their head roughened by conical osteoderms (bony deposits) beneath the scales. The Xenosauridae bear live offspring and protect them in burrows. They prey on insects and other animals.

KNOB-SCALED LIZARD
Xenosaurus grandis
A flat-bodied lizard found on the floor of Mexican rainforests, it feeds on flying insects at night. It remains hidden during the day.

NIGHT LIZARDS

The 30 or so Xantusiidae species are restricted to North and Central America. These secretive, viviparous lizards are crepuscular (active at twilight) or diurnal rather than nocturnal. They have a large headshield and rectangular belly scales.

YELLOW-SPOTTED NIGHT LIZARD
Lepidophyma flavimaculatum
Found among rotting logs in the wet forests of C. America, this species feeds on insects.

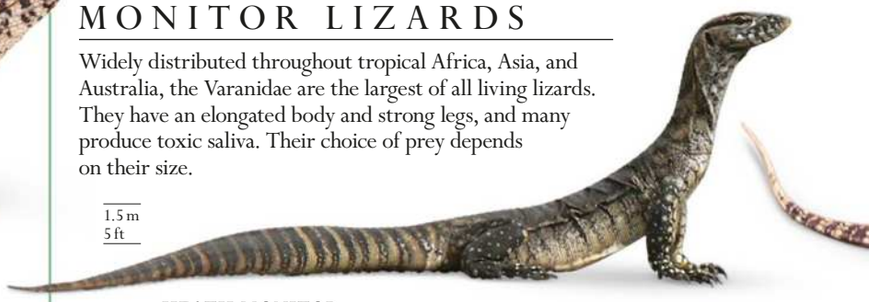
AMERICAN LEGLESS LIZARDS

Found only in the deserts of western North America, the Anniellidae comprises two species. They have a long, cylindrical body and a small head, and burrow to hunt invertebrates. They give birth to one or two live young.

CALIFORNIA LEGLESS LIZARD
Anniella pulchra
An insectivorous, worm-like lizard, this species burrows in sand or loose soil. It can detach its tail to trick predators.

MONITOR LIZARDS

Widely distributed throughout tropical Africa, Asia, and Australia, the Varanidae are the largest of all living lizards. They have an elongated body and strong legs, and many produce toxic saliva. Their choice of prey depends on their size.



HEATH MONITOR
Varanus rosenbergi
Found around the coasts of southern Australia, this monitor has a varied diet. It is a strong digger and often forages underground for food.

ASIAN WATER MONITOR
Varanus salvator
This monitor is found in rainforests and wet habitats of S. Asia. Its large size allows it to tackle a variety of prey.

SAVANNA MONITOR
Varanus exanthematicus
Found in the savanna of sub-Saharan Africa, this species forages for invertebrates and other animals small enough to swallow.

ANGUID LIZARDS

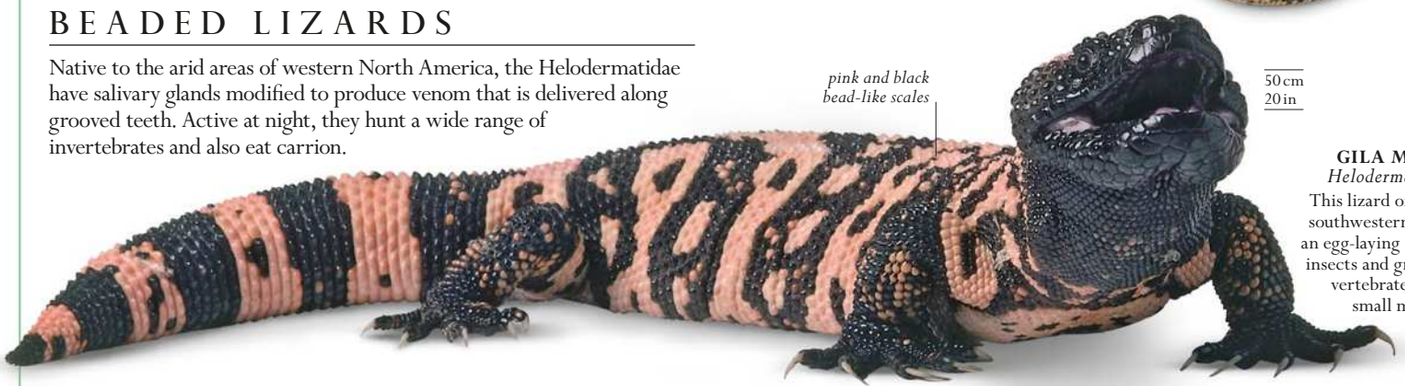
The Anguidae include both legless forms and species with normal limbs. Most lizards are surface dwellers and occur in a range of habitats in the Old and New Worlds. Though often insectivorous, these lizards will feed on a range of prey. They lay eggs.

SLOW WORM
Anguis fragilis
A legless lizard found in well-vegetated habitats across Europe, this species favours compost heaps, where it preys on invertebrates.

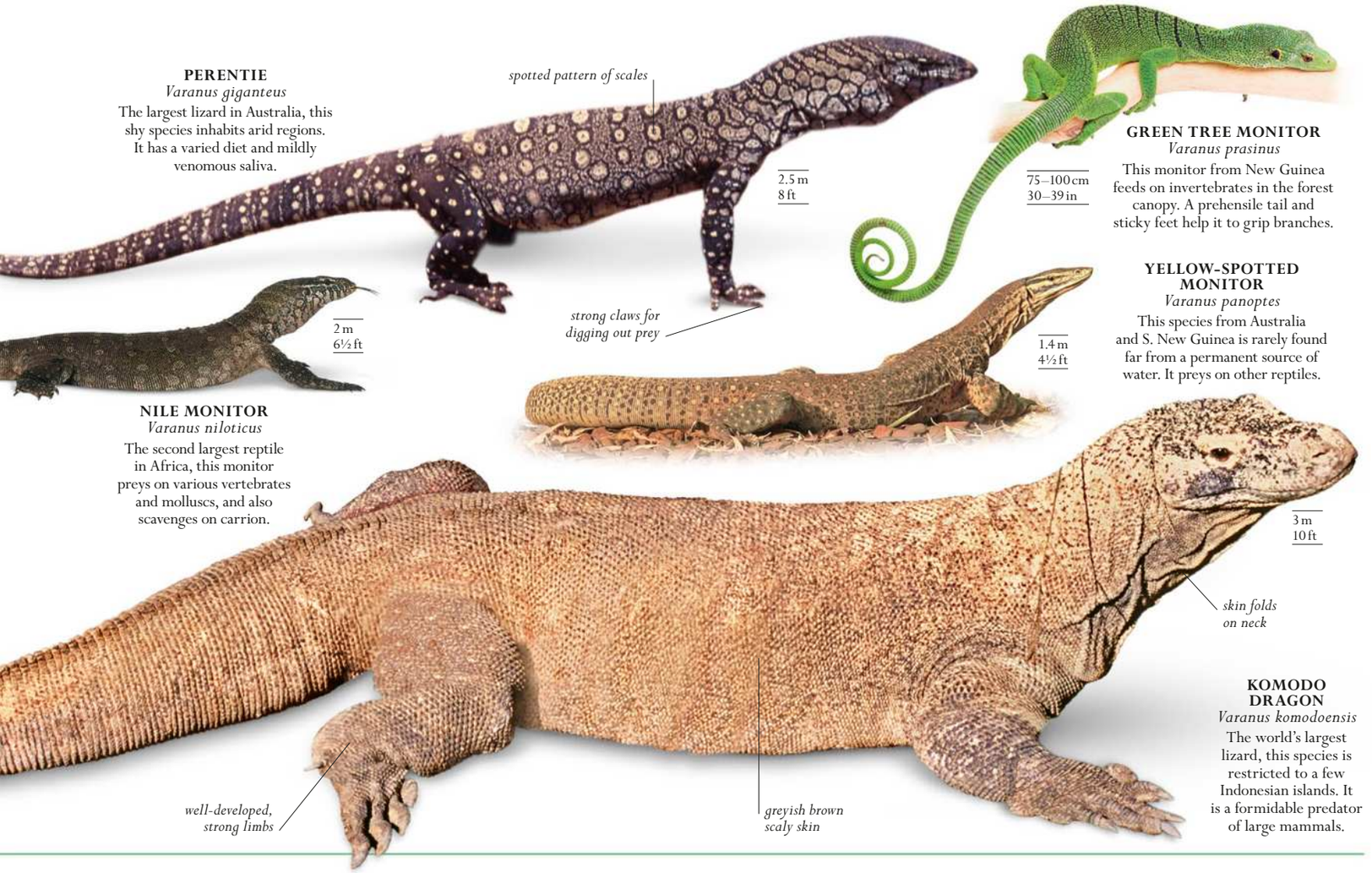
EUROPEAN GLASS LIZARD
Pseudopus apodus
Found in the dry habitats of S. Europe, this legless lizard hunts during the day for large insects and small lizards.

BEADED LIZARDS

Native to the arid areas of western North America, the Helodermatidae have salivary glands modified to produce venom that is delivered along grooved teeth. Active at night, they hunt a wide range of invertebrates and also eat carrion.



GILA MONSTER
Heloderma suspectum
This lizard of the deserts of southwestern N. America is an egg-laying species. It hunts insects and ground-dwelling vertebrates, including small mammals.


PERENTIE
Varanus giganteus
The largest lizard in Australia, this shy species inhabits arid regions. It has a varied diet and mildly venomous saliva.
spotted pattern of scales
2.5 m
8 ft
2 m
6½ ft
NILE MONITOR
Varanus niloticus
The second largest reptile in Africa, this monitor preys on various vertebrates and molluscs, and also scavenges on carrion.
strong claws for digging out prey
1.4 m
4½ ft
GREEN TREE MONITOR
Varanus prasinus
This monitor from New Guinea feeds on invertebrates in the forest canopy. A prehensile tail and sticky feet help it to grip branches.
75–100 cm
30–39 in
YELLOW-SPOTTED MONITOR
Varanus panoptes
This species from Australia and S. New Guinea is rarely found far from a permanent source of water. It preys on other reptiles.
3 m
10 ft
skin folds on neck
KOMODO DRAGON
Varanus komodoensis
The world's largest lizard, this species is restricted to a few Indonesian islands. It is a formidable predator of large mammals.
well-developed, strong limbs
greyish brown scaly skin

AMPHISBAENIANS

They may resemble legless lizards, but the burrowing reptiles in the suborder Amphisbaenia are quite distinct in their anatomy and behaviour.

The amphisbaenians, or worm-lizards, are reptiles wholly adapted to a subterranean lifestyle, spending almost their entire lives underground. Most species have lost all trace of their limbs and have elongated bodies with smooth scales.

They hunt for soil invertebrates by means of scent and sound, killing them in their crushing jaws. Burrowing involves the worm-lizard propelling itself forward by contracting and extending its body while the specially adapted head pushes through the soil. The eyes are protected by tough, translucent skin. Fertilization is internal, with some species laying eggs, others bearing live young. They are found in South America, Florida, Africa, the Middle East, and southern Europe.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (AMPHISBAENIANS)	6
SPECIES	195

WORM-LIZARDS

Amphisbaenians are burrowing reptiles with a head specially adapted for digging. They are found in Europe, sub-Saharan Africa and South America. They are formidable predators of soil invertebrates, hunting by scent and sound.

black and white markings
45 cm
18 in
SPECKLED WORM-LIZARD
Amphisbaena fuliginosa
This worm-lizard hunts invertebrates while burrowing through leaf litter in the rainforests of S. America. It surfaces during heavy rains.
rudimentary eye
EUROPEAN WORM-LIZARD
Blanus cinereus
Rarely seen above ground, this burrowing reptile from Spain and Morocco forages in leaf litter for invertebrates, particularly ants.
30 cm
12 in
17 cm
6½ in
LANG'S ROUND-HEADED WORM-LIZARD
Chirindia langi
Found in southern Africa, this species burrows through sandy soils to forage for termites. If caught, it can shed its tail in a bid to escape.

SNAKES

Snakes are predators with an elongated body and skin made up of overlapping scales. In a number of species modified teeth, or fangs, are used to deliver venom.

Although most numerous in tropical regions, snakes have adapted to live at colder latitudes and at altitude and are found on all continents except Antarctica. They are usually terrestrial with many living in trees, but some species burrow, some are semi-aquatic, and others live entirely in the sea. The smallest are tiny, thread-like creatures, but the largest can reach 10 m (33 ft) in length. Most are between 30 cm and 2 m (1–6½ ft).

A UNIQUE ARRAY OF SENSES

Some snakes have external vestiges of hind limbs, but they move by muscular contractions creating traction between the scales on their undersides and the surface beneath. A large number of flexibly linked vertebrae allows bending and coiling in any direction. The scaly skin is regularly shed to allow growth. Many snakes rely on just one elongated lung for breathing, while the gut is a simple tube with a large, muscular stomach. Instead of eyelids that can be opened and closed, each eye is covered by a clear, protective scale. Eyesight can be good, but varies according to lifestyle. Lacking external ears, snakes detect sounds as vibrations from the ground as well as in the air. Their key sense is smell, not through the nostrils, but from airborne chemicals collected by the forked tongue. Some species can also detect the body heat of mammals and birds.

KILLING TO LIVE

All snakes are carnivorous. Their sharp teeth curve backwards to grasp and hold prey. Whether they eat their victim alive or kill it by injection of venom or by constriction, they consume their prey whole. Their uniquely elastic jaws allow them to swallow animals much larger than a snake's own head. Snakes defend themselves by camouflage, warning coloration, or mimicry. When threatened, they may strike out and bite.

Species in cold places tend to bear live offspring, whereas those in warmer climates lay eggs. Fertilization is internal. The male deposits sperm by means of one of his paired sexual organs, known as hemipenes.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (SNAKES)	30
SPECIES	3,789

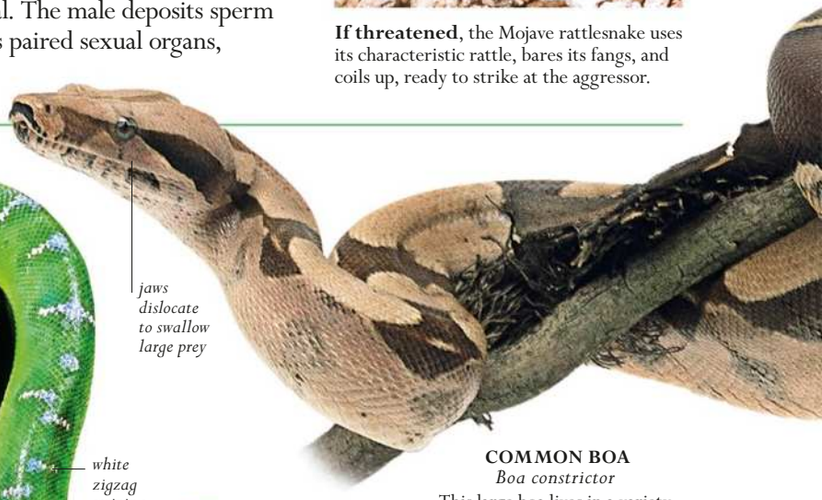
If threatened, the Mojave rattlesnake uses its characteristic rattle, bares its fangs, and coils up, ready to strike at the aggressor.

BOAS

The majority of Boidae are found in Central and South America, but a few species of boas are also present in Madagascar and New Guinea. These snakes are found from forests to marshes, where they prey on vertebrates, killing them by constriction. This family includes the anaconda, the largest living snake, and other species of varying sizes. Most give birth to live young.

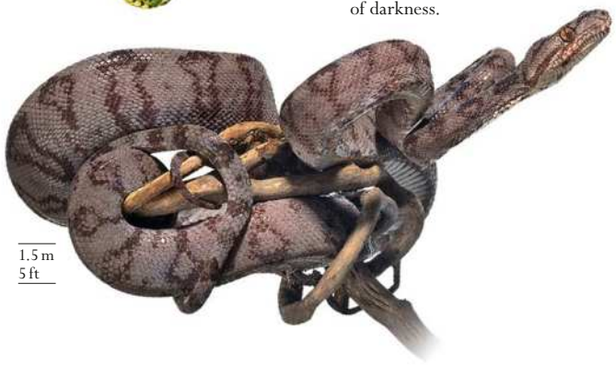
DUMERIL'S BOA
Acrantophis dumerili
Found in the humid forests of Madagascar, this snake becomes torpid when sheltering in burrows during the dry, cool months.

EMERALD TREE BOA
Corallus caninus
Found in rainforests of S. America, this arboreal snake preys on small mammals and sometimes birds. It has a slender body, long prehensile tail, and large head. The live young are brick-red or yellow-orange in colour, changing to emerald green at 12 months of age.



COMMON BOA
Boa constrictor
This large boa lives in a variety of habitats in C. and S. America. It is a nocturnal hunter of small mammals.

COOK'S TREE BOA
Corallus cookii
Endemic to St Vincent Island in the Caribbean, this rare snake hunts in trees for birds and mammals under the cover of darkness.



EAST AFRICAN SAND BOA
Gongylophis colubrinus
This African snake, with a stout body and short tail, waits in a burrow with only its head exposed to catch unsuspecting prey.

90 cm
35 in

1.1 m
3½ ft

head with small eyes

small, smooth scales assist in burrowing

head-like tail used in defence

CALABAR GROUND BOA
Calabaria reinhardtii
Native to W. Africa, the Calabar ground boa hunts in burrows for small mammals. It is the only egg-laying boa.

mottled brown coloration for camouflage

long, muscular body

2.5 m
8 ft

RAINBOW BOA
Epicrates cenchria
Microscopic ridges on the scales of this S. American snake refract light to give it an iridescent sheen. It hunts for mammals in forests.

2 m
6½ ft

smooth, glossy scales

1 m
3¼ ft

NEW GUINEA GROUND BOA
Candoia aspera
A sharply angled snout helps to identify this New Guinea snake. It is a slow-moving terrestrial hunter of small vertebrates.

80 cm
32 in

RUBBER BOA
Charina bottae
Preferring cool, humid conditions, this burrowing species is found at high altitudes and as far north as British Columbia.

10 m
33 ft

ROSY BOA
Lichanura trivirgata
This is a slow-moving snake from the deserts of the W. USA. It ambushes mammals and kills them by constriction.

1 m
3¼ ft

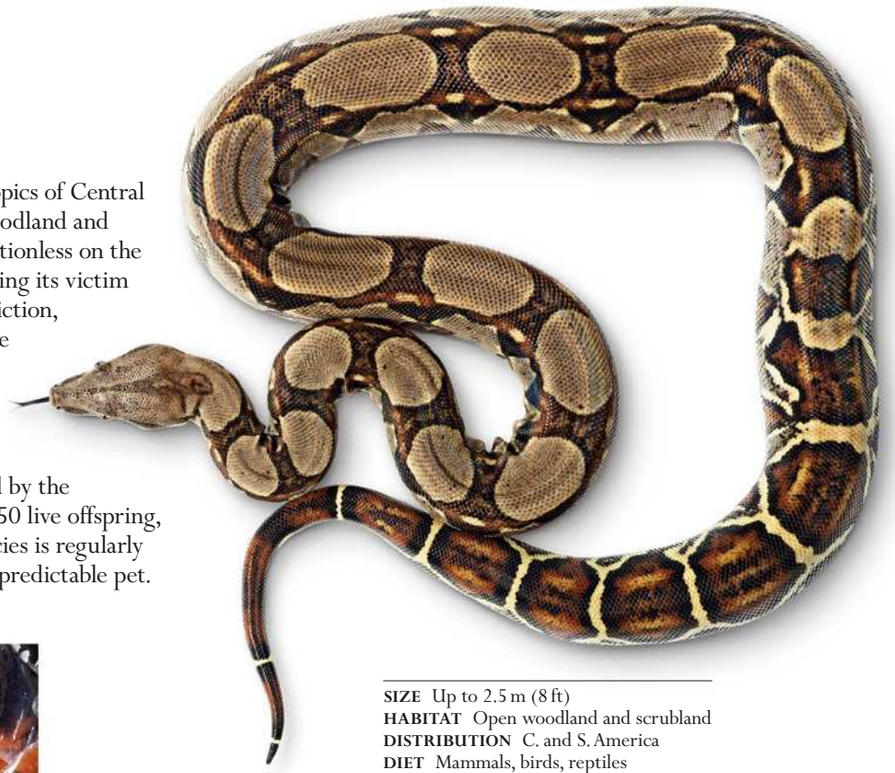
dull yellow colour with prominent black spots

thick, muscular body used to constrict prey

GREEN ANACONDA
Eunectes murinus
This aquatic S. American species is the largest of the New World snakes. It hides in water and kills its prey by constriction.

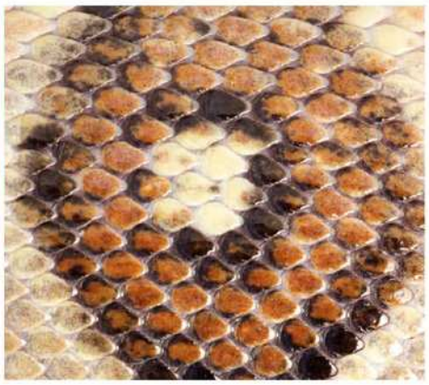
COMMON BOA
Boa constrictor

The common boa is a large terrestrial snake from the tropics of Central and South America. Although they are often found in woodland and scrub, boas easily adapt to a variety of habitats. Lying motionless on the ground, the snake ambushes its mammalian prey – grasping its victim with its jaws, it coils around the body and kills by constriction, tightening its coils with every exhalation of its prey. Once dead, the prey is swallowed head first. The left and right sides of the boa's lower jaw separate in front, and can open wide to take astonishingly large prey. Usually a solitary species, males will actively seek out a partner at breeding times, attracted by the scent emitted by the female. Larger than males, female boas give birth to 30–50 live offspring, each measuring around 30 cm (12 in) in length. This species is regularly seen in captivity but its propensity to bite makes it an unpredictable pet.



SIZE Up to 2.5 m (8 ft)
HABITAT Open woodland and scrubland
DISTRIBUTION C. and S. America
DIET Mammals, birds, reptiles

^ COLOUR VARIANTS
There are numerous subspecies of common boa, which are defined on the basis of size and colour patterns. Colour also varies considerably between localities.



> CAMOUFLAGE
Pigmentation of some scales forms patches of colour that disrupt the outline of the snake. This helps with camouflage when hunting prey or evading predators.

^ BELLY SCALES
The robust belly scales grip most surfaces, allowing the common boa to pull itself along and climb trees. It periodically sheds its skin.

> SIZEABLE FOE
The common boa hunts by sight and smell, so the eyes and nostrils are prominent on the triangular head. Feeding can be infrequent – a small prey item may last a snake two to three weeks. A large snake that kills a deer will not need to feed for at least six months.

distinctive, saddle-like markings

even when closed, the mouth has an opening that allows the tongue to be extended

forked tongue

< EYE
The boa has keen eyesight, and the pupil narrows to a slit in bright light. It has no eyelids. Around the eyes, the head is covered with numerous small scales, which are made of keratin.

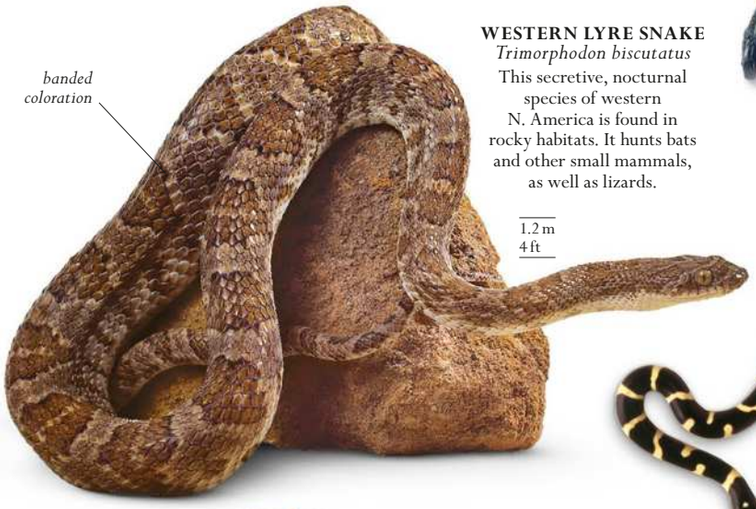
REMNANT LIMBS ^ >
All snakes lack limbs, but more primitive species like the common boa still possess the remnants of a pelvis, as well as tiny, spur-like hind limbs on each side of the anal vent – these would once have been legs.

TONGUE FLICKING ^
The forked tongue is an important sense organ. Snakes flick their tongues, collecting chemicals from the air; these are then analysed by the Jacobson's organ in the roof of the mouth.

COLUBRIDS

With around 2,000 species worldwide, colubrids form the largest family of snakes. The members of the family Colubridae inhabit a wide range of habitats, from deserts to wetlands. They have a varied diet. Many species lay eggs.

COMMON GARTER SNAKE
Thamnophis sirtalis
This N. American species is active during daytime, hunting vertebrates in a range of habitats. In Manitoba, after hibernation it congregates in large numbers to mate.



WESTERN LYRE SNAKE
Trimorphodon biscutatus
This secretive, nocturnal species of western N. America is found in rocky habitats. It hunts bats and other small mammals, as well as lizards.

RUTHVEN'S KINGSNAKE
Lampropeltis ruthveni
An egg-laying species, this colubrid is from the Mexican plateau, where it hunts rodents and lizards in dry woodland.

GREY EARTHSNAKE
Geophis brachycephalus
This small, C. American snake is terrestrial and nocturnal. It feeds mainly on earthworms and soft insect larvae.

LONG-NOSED SNAKE
Rhinocheilus lecontei
Characterized by a pointed snout, this shy, nocturnal, burrowing species is from dry grasslands of N. America, where it hunts lizards.

CALIFORNIA MOUNTAIN KINGSNAKE
Lampropeltis zonata
This secretive snake prefers high-altitude wooded habitats. It is typically nocturnal, but is diurnal when nights are cold.

AFRICAN EGG-EATING SNAKE
Dasypeltis scabra
This African snake has a highly specialized diet of eggs on which it feasts during the bird-nesting season. It then fasts for the rest of the year.

PINE SNAKE
Pituophis melanoleucus
When threatened, this large, powerful snake of woodlands in N. America ejects foul-smelling waste from its rear opening (cloaca).

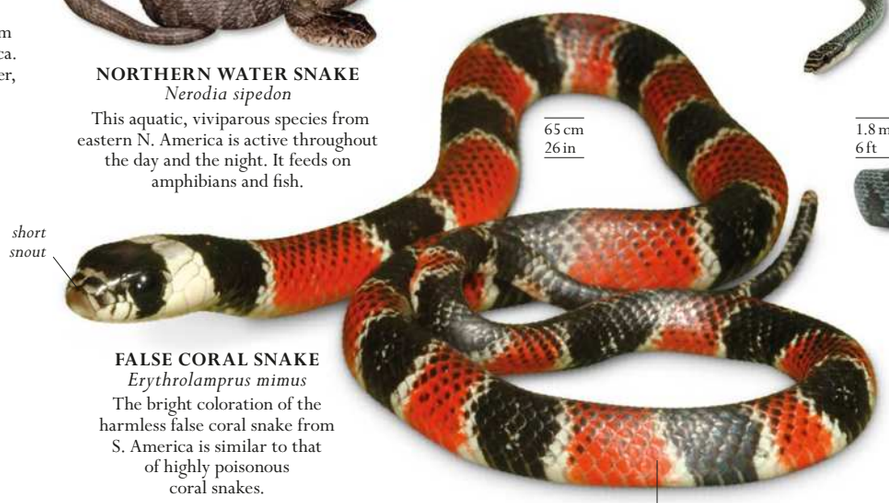
GREEN HIGHLAND RACER
Drymobius chloroticus
This fast, agile snake is from the rainforests of C. America. It is usually found near water, where it feeds on frogs.

WESTERN INDIGO SNAKE
Drymarchon corais
This is one of the longest snakes in N. America. It often shares a burrow with the gopher tortoise.

NORTHERN WATER SNAKE
Nerodia sipedon
This aquatic, viviparous species from eastern N. America is active throughout the day and the night. It feeds on amphibians and fish.

BANDED FLYING SNAKE
Chrysopelea pelias
Despite its name, this S. Asian snake does not actively fly. Instead, it glides down from high branches by making its underside concave.

MUD SNAKE
Farancia abacura
This N. American snake preys on aquatic salamanders, grasping them with strongly curved teeth. Females remain coiled around their eggs until they hatch.



FALSE CORAL SNAKE
Erythrolamprus mimus
The bright coloration of the harmless false coral snake from S. America is similar to that of highly poisonous coral snakes.

MOELLENDORFF'S RATSNAKE
Elaphe moellendorffi
This species is from dry limestone regions of China and Vietnam. It has an elongated snout and a relatively long tail.

REDBACK COFFEE SNAKE
Ninia sebae
This harmless snake from C. America has an ability to extend its neck as a form of intimidation.

NORTHERN CAT-EYED SNAKE
Leptodeira septentrionalis
This nocturnal, arboreal species from C. America has large eyes to help it hunt for vertebrates and eggs of tree frogs.

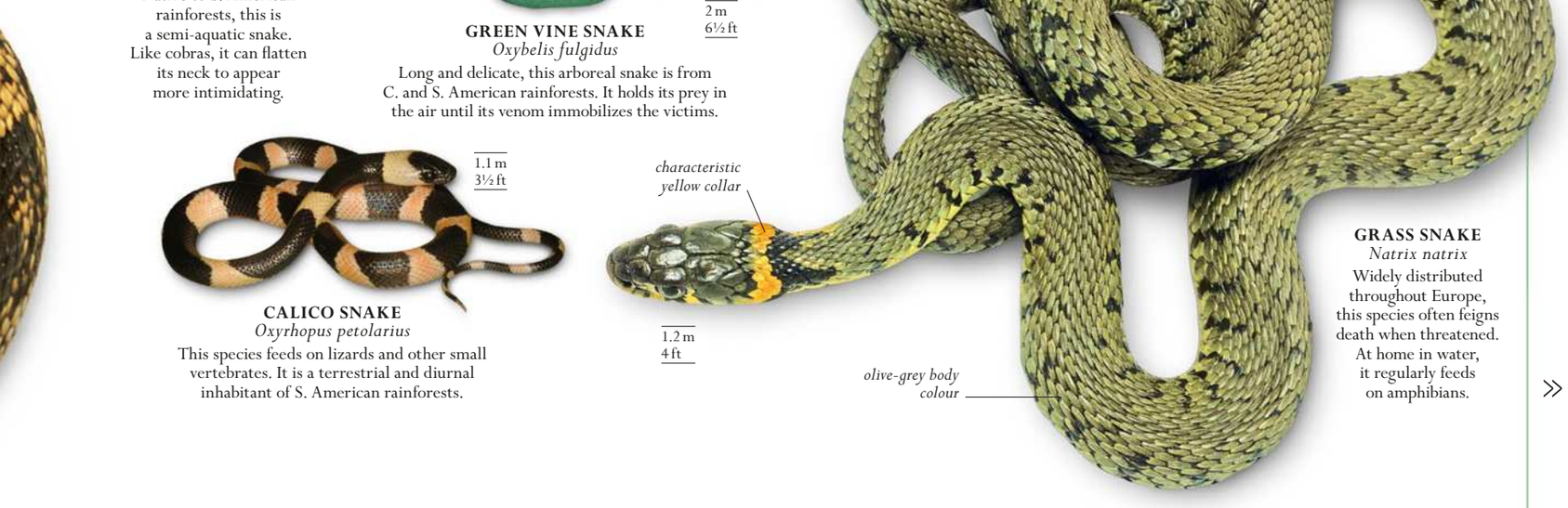
BROWN BLUNT-HEADED VINE SNAKE
Imantodes cenchoa
The large eyes of this slender snake help it hunt lizards in the dark. It is found in tropical American rainforests.

BROWN TREESNAKE
Boiga irregularis
Originally from Australia and New Guinea, this snake was accidentially introduced on the island of Guam in the W. Pacific, where it has decimated the native fauna.

FALSE WATER COBRA
Hydrodynastes gigas
Native to S. American rainforests, this is a semi-aquatic snake. Like cobras, it can flatten its neck to appear more intimidating.

GREEN VINE SNAKE
Oxybelis fulgidus
Long and delicate, this arboreal snake is from C. and S. American rainforests. It holds its prey in the air until its venom immobilizes the victims.

CALICO SNAKE
Oxyrhopus petolarius
This species feeds on lizards and other small vertebrates. It is a terrestrial and diurnal inhabitant of S. American rainforests.



GRASS SNAKE
Natrix natrix
Widely distributed throughout Europe, this species often feigns death when threatened. At home in water, it regularly feeds on amphibians.

»

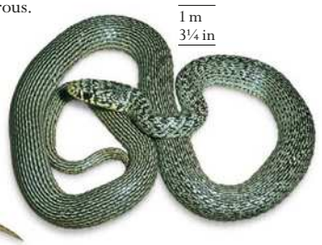
» COLUBRIDS

COMMON TRINKET SNAKE
Coelognathus helena
This Indian species enlarges its neck and rises up to intimidate its enemies. It hunts mammals, usually at night.

ROUGH GREEN SNAKE
Opheodrys aestivus
Native to woodlands in southeastern N. America, this arboreal snake is a diurnal predator of insects. It is oviparous.

RED-TAILED GREEN RATSNAKE
Gonyosoma oxycephalum
This fast-moving snake hunts for birds and mammals in trees. It is found in the rainforests of S.E. Asia.

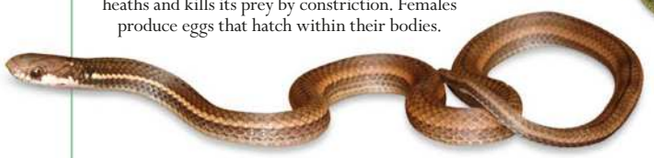
SMOOTH SNAKE
Coronella austriaca
This secretive European snake is found on heaths and kills its prey by constriction. Females produce eggs that hatch within their bodies.



BALKAN WHIPSNAKE
Hierophis gemonensis
Restricted to the Balkans, this snake is found in dry scrubland and olive groves. It hunts during the day, preying on lizards.

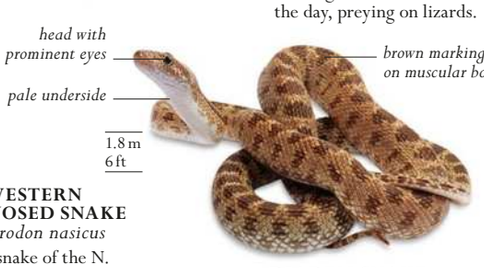
DAHL'S WHIPSNAKE
Platyceps najadum
From the Mediterranean region, this snake is found in dry, stony habitats. It hunts small lizards and grasshoppers during the day.

SOUTHERN WATER SNAKE
Nerodia fasciata
Living in wetlands, this colubrid preys on amphibians and fish. It is found in the S. USA.



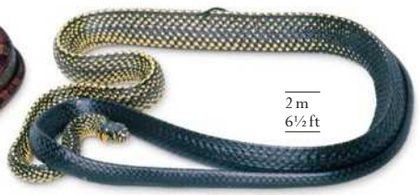
BROWN-HEADED CENTIPEDE SNAKE
Tantilla ruficeps
This burrowing snake is found in the tropical forests of C. America. It is a mainly diurnal insect-eater.

WESTERN HOGNOSED SNAKE
Heterodon nasicus
This snake of the N. American prairies uses its specialized, enlarged teeth to puncture the lungs of toads, making them easier to swallow.



DIADEM SNAKE
Spalaerosophis diadema cliffordi
Native to deserts in N. Africa, this subspecies is diurnal during cooler months, but turns nocturnal during summer months.

RED CORNSNAKE
Pantherophis guttatus
This snake is common in southeastern N. America, but is rarely seen. It hunts small mammals in woodland.



YELLOW RATSNAKE
Spilotes pullatus
A predator of small vertebrates, this large snake is rarely found far from water. It is widely distributed in S. and C. America.

LAMPROPHIIDAE

Found mainly in Africa, the diverse lamprophiid snakes occupy varied habitats – terrestrial, arboreal, and semi-aquatic. Predating a range of vertebrates and invertebrates, they subdue their prey by either constriction or venom.

MOLE VIPER
Atractaspis fallax
This poisonous snake from E. Africa has large front fangs. It hunts other burrowing vertebrates underground.

GIANT MALAGASY HOGNOSE SNAKE
Leioheterodon madagascariensis
This large, diurnal snake, with an upturned snout, hunts lizards and amphibians in grasslands and forests in Madagascar.

MONTPELLIER SNAKE
Malpolon monspessulanus
Inhabiting dry scrub and rocky hillsides around the Mediterranean, this long, slender snake hunts small vertebrates during the day.

ASIAN PIPE SNAKES

Found in Sri Lanka and S.E. Asia, these small, burrowing snakes of the Cylindrophiidae have a cylindrical body and smooth, shiny scales. They live in wet habitats, sheltering in tunnels, but emerge at night to hunt other snakes and eels. They give birth to live young.

CEYLONESE PIPE SNAKE
Cylindrophis maculatus
Endemic to Sri Lanka, this harmless burrowing snake eats invertebrates. It uses its flattened tail to mimic the movements of the venomous cobra.

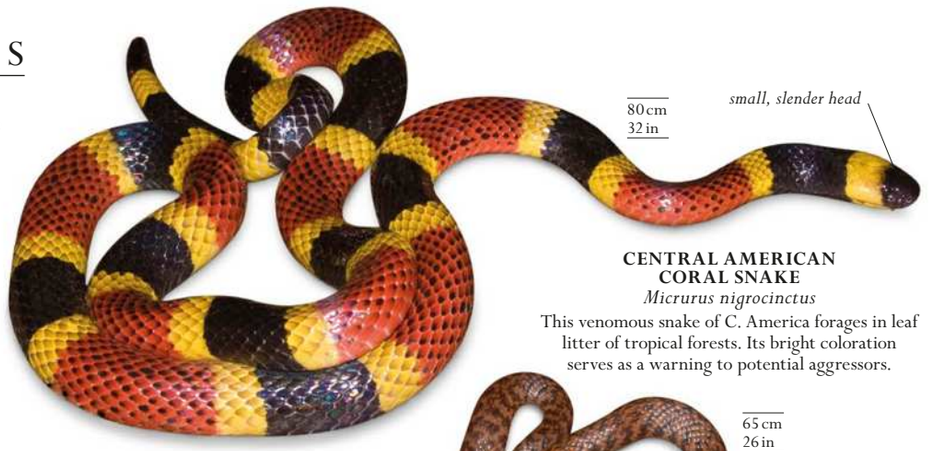
SEA SNAKES

These highly venomous snakes from the tropical coastal waters of the Indian and Pacific oceans belong to the subfamily Hydrophiinae, part of the larger Elapidae. They are well adapted for swimming, with a paddle-like tail. All but a few breed in water, bearing live young. They eat eels and other fish.

YELLOW-LIPPED SEAKRAIT
Laticauda colubrina
This snake hunts fish at night in tropical Indo-Pacific seas. It can move on land as well.

COBRAS AND RELATIVES

Widely distributed in the tropics, the venomous snakes of the Elapidae have short, permanently erect fangs at the front of the mouth. Varied in body forms, they occupy a wide variety of habitats. Some species lay eggs, while others bear live young.



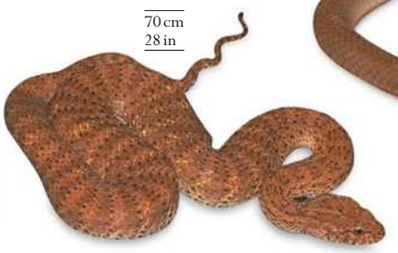
CENTRAL AMERICAN CORAL SNAKE
Micrurus nigrocinctus
This venomous snake of C. America forages in leaf litter of tropical forests. Its bright coloration serves as a warning to potential aggressors.

YELLOW-FACED WHIP SNAKE
Demansia psammophis
Widely distributed across Australia, this slender snake is an active diurnal hunter of lizards. It prefers dry, open habitats.

EASTERN SHIELD-NOSE SNAKE
Aspidelaps scutatus fulafulus
This nocturnal predator of small lizards and mammals is found in southern African savanna. It burrows in sandy soil.

ROSEN'S SNAKE
Suta fasciata
Found in arid areas of Western Australia, this venomous snake hunts for lizards.

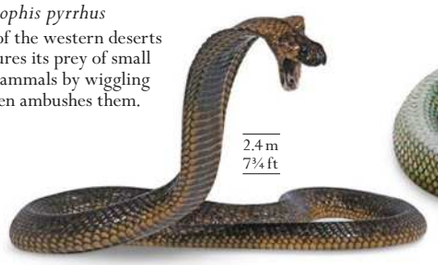
MONOCLED COBRA
Naja kaouthia
Common in S.E. Asia, this large snake hunts rats and other snakes in woodland and paddy fields, often close to human habitation.



DESERT DEATH ADDER
Acanthophis pyrrhus
This predator of the western deserts of Australia lures its prey of small lizards and mammals by wiggling its tail. It then ambushes them.

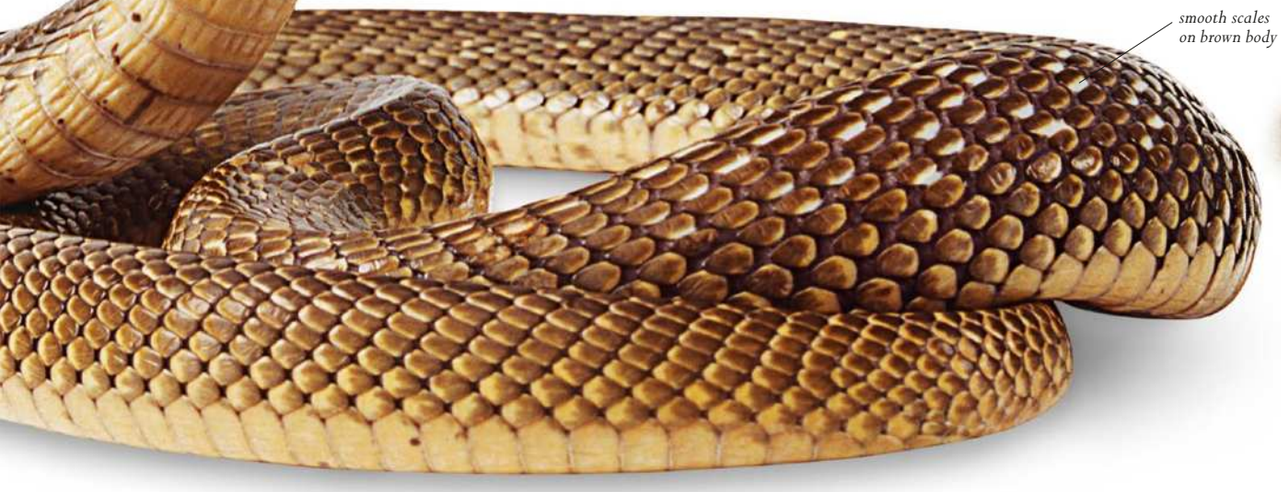
RINGED BROWN SNAKE
Pseudonaja modesta
Found in dry, rocky areas in Australia, this venomous snake feeds on small skinks. Its survival is threatened by the loss of its habitat.

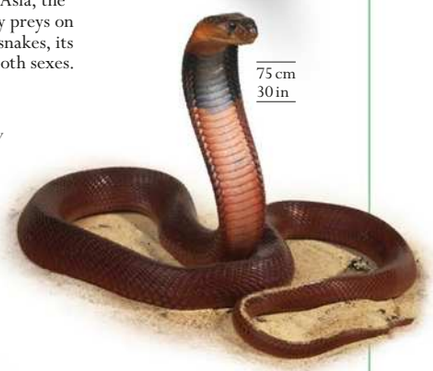
SOUTHERN DESERT BANDED SNAKE
Simoselaps bertholdi
Widespread in Western Australia, this small snake burrows in search of its lizard prey. The banding may confuse predators.



EGYPTIAN COBRA
Naja haje
This large cobra hunts small vertebrates in the deserts of N. and C. Africa. When threatened, it spreads its hood and raises its head.

KING COBRA
Ophiophagus hannah
A forest species of tropical Asia, the massive king cobra primarily preys on other snakes. Unusually for snakes, its nest of eggs is defended by both sexes.





RED SPITTING COBRA
Naja pallida
This African species not only raises its hood when threatened, but also sprays streams of venom into the face of its aggressor.

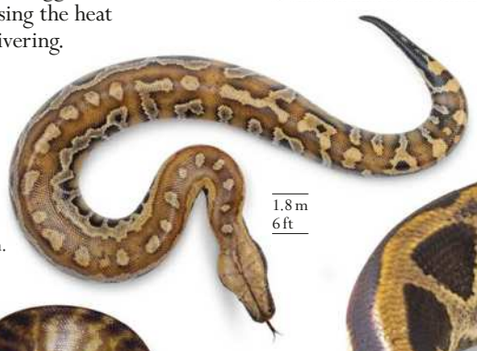
PYTHONS

Members of the family Pythonidae can be found across Africa, Asia, and Australia. Pythons detect warm-blooded prey with their facial pits. They use their mouth to grasp prey but kill by constriction. Some species coil around their eggs to help incubate them using the heat generated by their shivering.

1.5 m
5 ft

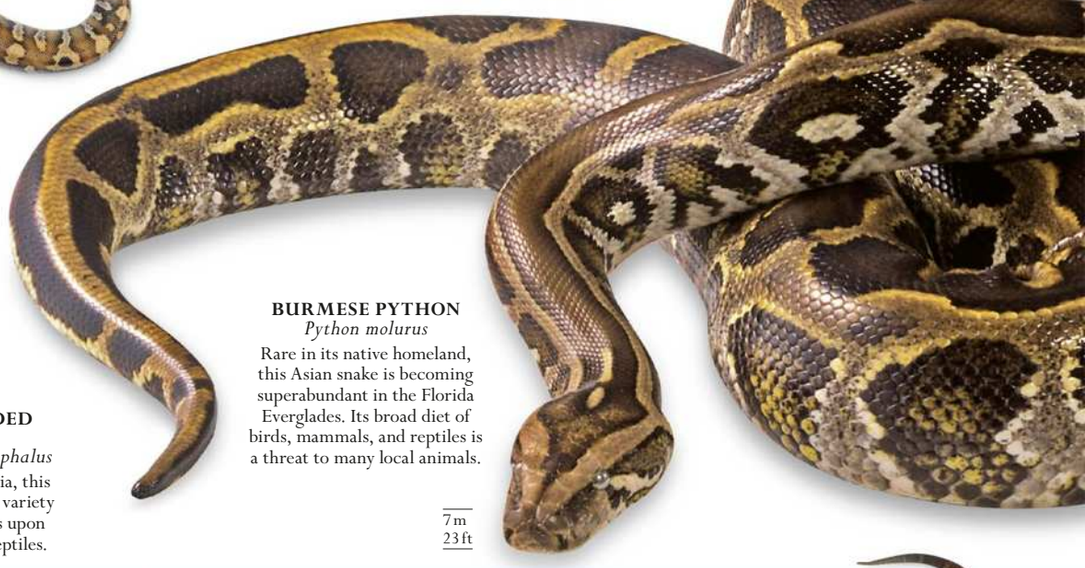
GREEN TREE PYTHON
Morelia viridis
Found in the tropical forests of Australasia, this arboreal snake spends its time looped over a branch, ready to ambush lizards and small mammals.

bright green colour aids in camouflage



BLOOD PYTHON
Python curtus
This relatively short python of S.E. Asian rainforests coils around its clutch of eggs to incubate and protect them.

1.8 m
6 ft



3 m
10 ft

BLACK-HEADED PYTHON
Aspidites melanocephalus
Endemic to Australia, this species is found in a variety of habitats. It preys upon other snakes and reptiles.

BURMESE PYTHON
Python molurus
Rare in its native homeland, this Asian snake is becoming superabundant in the Florida Everglades. Its broad diet of birds, mammals, and reptiles is a threat to many local animals.

7 m
23 ft

BLIND SNAKES

The Typhlopidae have eyes covered with scales, rendering them effectively blind. Found in leaf litter of tropical forests, these small, burrowing snakes mainly eat soil invertebrates and have teeth only on their upper jaw. Most of them lay eggs.

35 cm
14 in

EURASIAN BLIND SNAKE
Xerotyphlops vermicularis
This worm-like blind snake from Europe inhabits dry, open areas. It burrows to feed on invertebrates, mainly ant larvae.

75 cm
30 in

BLACKISH BLIND SNAKE
Anilios nigrescens
Tough scales allow this burrowing snake from E. Australia to resist attack from ants while eating their eggs and larvae.

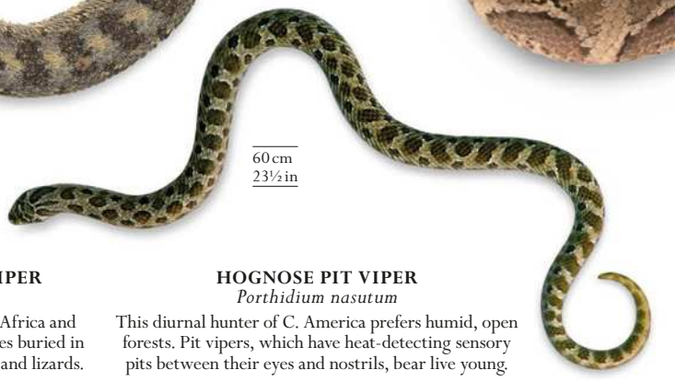
VIPERS

The Viperidae are characterized by a thick body, keeled scales, and a triangular head. Long, tubular, hinged fangs at the front of the mouth efficiently inject venom into their vertebrate prey. Pit vipers have sensory pits between their eyes and nostrils that detect heat. Most vipers bear live young.

1.5 m
5 ft

FER-DE-LANCE
Bothrops atrox
Found in the forests of tropical America, this venomous snake is characterized by a sharply pointed head. It hunts birds and mammals by night.

85 cm
34 in



60 cm
23½ in

DESERT HORNED VIPER
Cerastes cerastes
Occurring in the deserts of N. Africa and the Sinai Peninsula, this snake lies buried in sand to ambush small mammals and lizards.

HOGNOSE PIT VIPER
Porthidium nasutum
This diurnal hunter of C. America prefers humid, open forests. Pit vipers, which have heat-detecting sensory pits between their eyes and nostrils, bear live young.

THREAD SNAKES

These small, slender snakes are rarely seen because of their habit of burrowing to hunt invertebrates. Belonging to the Leptotyphlopidae, they are found in the tropics of the Americas, Africa, and southwest Asia.

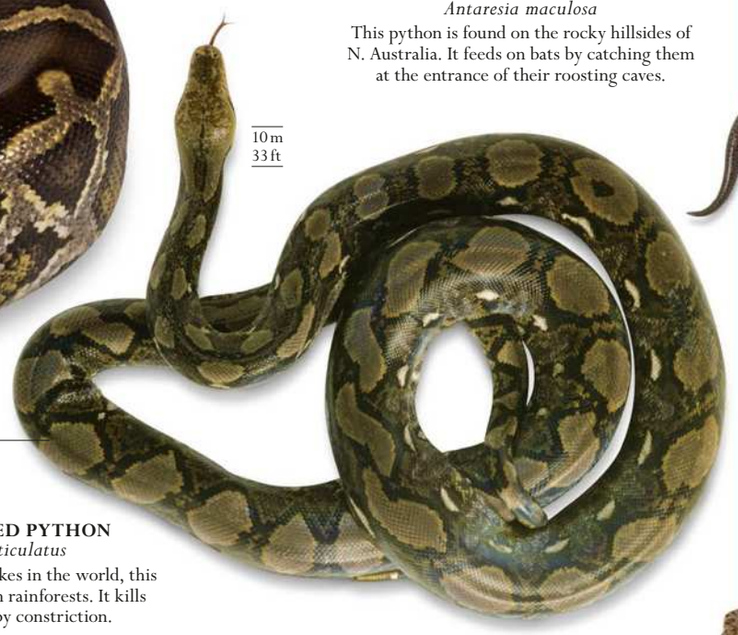
30 cm
12 in

SENEGAL BLIND SNAKE
Myriopholis rouxestevae
This snake inhabits the soil of tropical forests in western Africa. First studied in 2004, it is believed to eat invertebrates.

SUNBEAM SNAKES

Characterized by iridescent scales, the Xenopeltidae include only two species, both restricted to Southeast Asia. They live in burrows in forest habitats and hunt amphibians, other reptiles, and small mammals. They reproduce by laying eggs.

SPOTTED PYTHON
Antaresia maculosa
This python is found on the rocky hillsides of N. Australia. It feeds on bats by catching them at the entrance of their roosting caves.



RETICULATED PYTHON
Python reticulatus
One of the longest snakes in the world, this species inhabits Asian rainforests. It kills large mammals by constriction.

SUNBEAM SNAKE
Xenopeltis unicolor
A flat head helps this snake burrow into decaying vegetation. It emerges at dust to feed on amphibians and small mammals.

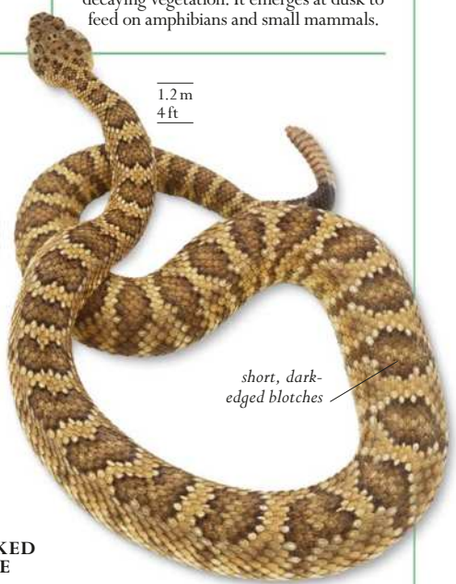
COPPERHEAD
Agkistrodon contortrix
Banded markings help this snake to hide in leaf litter in rocky woodland. It is found in eastern N. America.

ASP VIPER
Vipera aspis
This European viper prefers warm, dry habitats, where it feeds on small mammals. It bears up to 20 live young.

COMMON ADDER
Vipera berus
This diurnal species hunts small mammals and lizards. It is widely distributed across a variety of habitats in Eurasia.

WEST AFRICAN GABOON VIPER
Bitis rhinoceros
Occurring in tropical rainforests in Africa, this large, heavily built snake preys on mammals by ambushing them.

WESTERN DIAMOND-BACKED RATTLESNAKE
Crotalus atrox
A nocturnal hunter of mammals, this large snake is widespread in arid areas of western N. America.



PRAIRIE RATTLESNAKE
Crotalus viridis
This snake from the mid-western USA hunts mammals around dawn and dusk. It hides in crevices by day.

PUFF ADDER
Bitis arietans
Most active at night, this venomous snake usually lies still to ambush its vertebrate prey. It is found in rocky grassland in Africa.

MALAYAN PIT VIPER
Calloselasma rhodostoma
Occurring in S.E. Asia, this species forages by night in open areas adjacent to forests for rodents and lizards.

CROCODILES AND ALLIGATORS

Crocodilians are large, carnivorous, aquatic reptiles. Their armoured skin and powerful jaws make them formidable predators, yet they are sociable animals and caring parents.

All crocodilians – crocodiles, alligators, and gharials – have a similar body plan: an elongated snout armed with numerous, sharp, unspecialized teeth, a streamlined body, a long, muscular tail, and skin armoured with bony plates. The saltwater crocodile is the largest living reptile.

SWIMMING AND FEEDING

Crocodilians are found in tropical regions worldwide, inhabiting a variety of freshwater and marine habitats. The eyes, ears, and nostrils are on top of the head, which enables the animal to be almost completely submerged while hunting. The powerful tail is used for swimming and strong legs allow crocodilians to move readily on land with the body raised well above the ground.

Although generalist carnivores, feeding on fish, reptiles, birds, and mammals, crocodilians exhibit sophisticated feeding behaviours to locate and ambush specific prey, such as migrating mammals and fish. Small prey is swallowed whole but large prey is first drowned before the crocodilian rolls over while grasping the carcass to twist off pieces of meat. Digestion is aided by stones in the stomach and highly acidic gastric secretions.

SOCIAL BEHAVIOUR AND BREEDING

Behaviourally, crocodilians have more in common with birds, their closest living relatives, than with other reptiles. Adults form loose groupings – particularly at good feeding sites – and use a wide range of vocalizations and body language to interact with each other.

In the breeding season, dominant males control territories and actively court females. Fertilization is internal and clutches of rigid-shelled eggs are laid in a nest constructed and guarded by the female. The sex of individuals is determined by the incubation temperature. Hatchlings call to stimulate the female to excavate the nest and carry them in her mouth to water. Mortality is high in young crocodilians but once they are longer than 1 m (3¼ ft), they have few natural enemies.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	CROCODYLIA
FAMILIES	3
SPECIES	25

Exploiting a fast-flowing stream, these Yacare caimans lie in wait with their mouth held open, waiting for a fish to come within reach.

GHARIALS

The endangered Gavialidae are restricted to India. The slender snout has rows of numerous sharp teeth that help to catch fish. Males develop a wart-like growth on the tip of the snout.

GHARIAL
Gavialis gangeticus
Among the largest of the Crocodylia, this Asian species has a fearsome array of teeth, which help it to catch fish, but it is not known to attack humans.

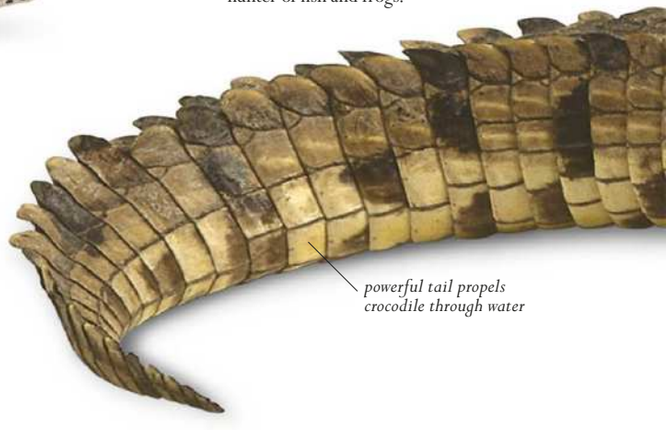
CROCODILES

Relatively unspecialized in lifestyle, habitat, and diet, the Crocodylidae are most easily recognized by the exposure of the fourth tooth of the lower jaw, when the jaws are closed. These tropical reptiles occupy many habitats around rivers and coasts.

DWARF CROCODILE
Osteolaemus tetraspis
From the forests of tropical Africa, this small crocodile has a heavy armour of scales on its neck and back. It is a nocturnal hunter of fish and frogs.

CUBAN CROCODILE
Crocodylus rhombifer
Endemic to Cuba, this medium-sized crocodile inhabits swamps, and hunts fish and small mammals. It lays its eggs in holes in the ground.

SIAMESE CROCODILE
Crocodylus siamensis
Restricted to S.E. Asia, this large crocodile is critically endangered in the wild. Found in freshwater marshes, it feeds on a variety of prey.



ALLIGATORS AND CAIMANS

Members of the family Alligatoridae feed on fish, birds, and mammals that share their aquatic habitat. These reptiles are distributed throughout freshwater swamps and rivers of the tropical and subtropical Americas. The only species living outside the Americas is the rare Chinese alligator.

AMERICAN ALLIGATOR
Alligator mississippiensis
Conservation efforts have now made this N. American species quite common. It preys on birds, small mammals, and turtles.

SPECTACLED CAIMAN
Caiman crocodilus
This caiman feeds on a wide range of prey. Widespread in C. and S. America, it appears to be the only crocodilian that readily occupies man-made aquatic habitats.

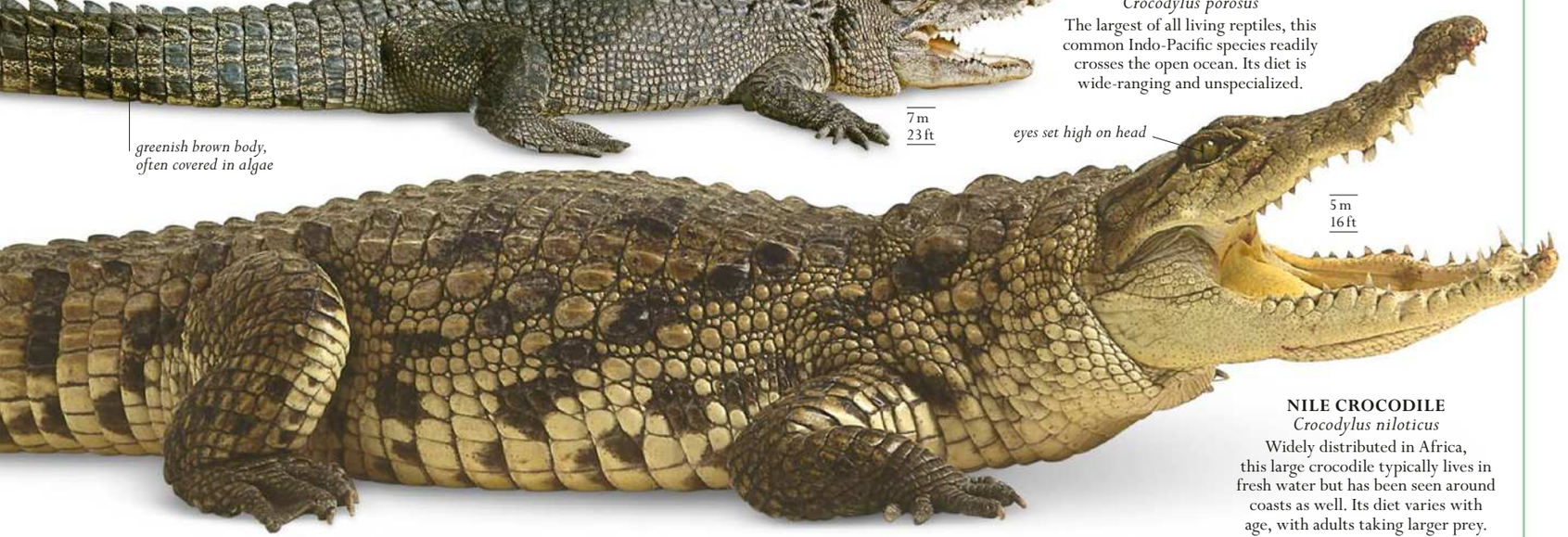
CHINESE ALLIGATOR
Alligator sinensis
This critically endangered species of the Yangtze valley of China lies dormant in burrows during the cold winter months.

BROAD-SNOUTED CAIMAN
Caiman latirostris
A mound-nesting species found across much of central S. America, this caiman is characterized by a broad snout. It hunts mammals and birds.

CUVIER'S DWARF CAIMAN
Paleosuchus palpebrosus
This S. American species is the smallest of the New World members of this order. It has a dog-like skull and bony armoured skin.

SCHNEIDER'S DWARF CAIMAN
Paleosuchus trigonatus
This small crocodile of S. American rainforests is semi-terrestrial. It builds its nest against a termite mound, which keeps the eggs warm.

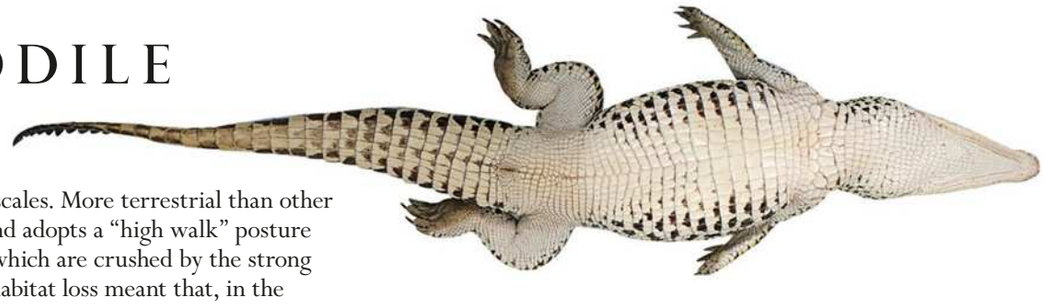
SALTWATER CROCODILE
Crocodylus porosus
The largest of all living reptiles, this common Indo-Pacific species readily crosses the open ocean. Its diet is wide-ranging and unspecialized.



NILE CROCODILE
Crocodylus niloticus
Widely distributed in Africa, this large crocodile typically lives in fresh water but has been seen around coasts as well. Its diet varies with age, with adults taking larger prey.

CUBAN CROCODILE
Crocodylus rhombifer

This strikingly coloured crocodile is native to Cuba. It is medium-sized, robust, and armoured with bony scales. More terrestrial than other crocodilian species, it raises its belly off the ground and adopts a "high walk" posture when moving on land. Its preferred prey are turtles, which are crushed by the strong teeth at the rear of its mouth. Hunting pressure and habitat loss meant that, in the 1960s, the few remaining wild Cuban crocodiles were captured and released into Zapata Swamp, a reserve in the south of the island. Although protected, the population remains small, and hybridization with American crocodiles on the reserve threatens the purity of this species.



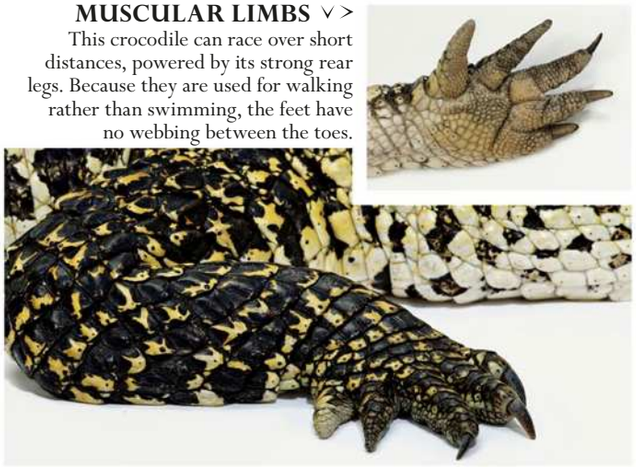
SIZE 3–3.5 m (9¾–11 ft)
HABITAT Freshwater swamps
DISTRIBUTION Cuba
DIET Fish, turtles, small mammals

large scales armoured with bony deposits

bony projections at back of the head resemble horns

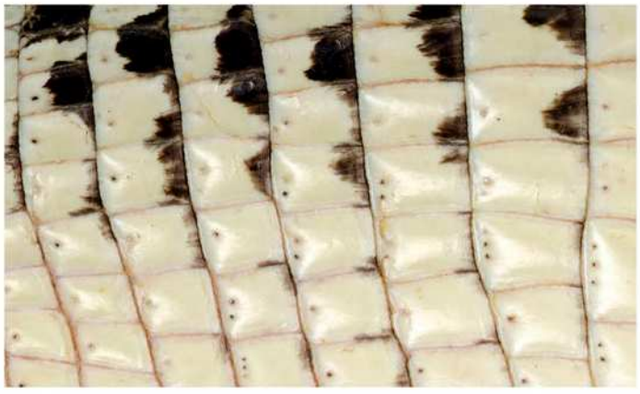
external ear flap, which is closed while the crocodile is under water

MUSCULAR LIMBS ∨ >
This crocodile can race over short distances, powered by its strong rear legs. Because they are used for walking rather than swimming, the feet have no webbing between the toes.



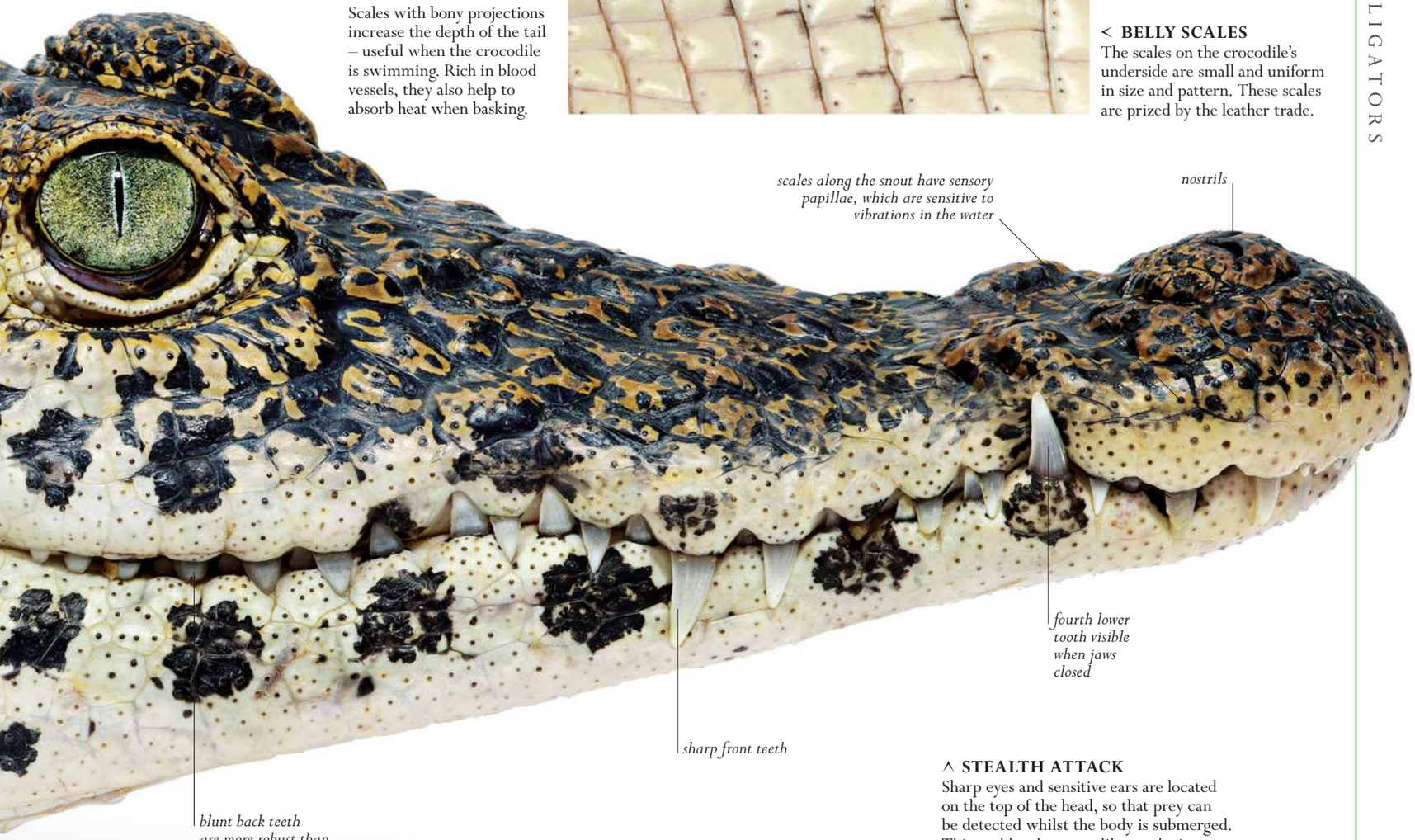
∨ NOSTRILS
Paired nostrils are located on the nasal disc, an elevated pad of tissue at the end of the snout. Under water, the nostrils can be closed by valves.

∧ TAIL RIDGE
Scales with bony projections increase the depth of the tail – useful when the crocodile is swimming. Rich in blood vessels, they also help to absorb heat when basking.



∧ FORMIDABLE JAWS
Crocodiles cannot chew their food, but they use their powerful jaws to grasp their prey. Sensitive taste buds on the tongue allow the crocodile to reject unpleasant tasting objects. Evaporation from the mouth cools the body.

< BELLY SCALES
The scales on the crocodile's underside are small and uniform in size and pattern. These scales are prized by the leather trade.


scales along the snout have sensory papillae, which are sensitive to vibrations in the water
nostrils
fourth lower tooth visible when jaws closed
sharp front teeth
blunt back teeth are more robust than the front teeth

∧ STEALTH ATTACK
Sharp eyes and sensitive ears are located on the top of the head, so that prey can be detected whilst the body is submerged. This enables the crocodile to take its victims by surprise. The long lower jaw can be closed with tremendous force to grasp struggling prey securely.

BIRDS

Birds have busy, active lives. Many are spectacularly beautiful; others sing complex – even musical – songs. They have the intelligence and parental devotion of a mammal combined with characteristics more reminiscent of a reptilian ancestor.

PHYLUM	CHORDATA
CLASS	AVES
ORDERS	40
FAMILIES	250
SPECIES	10,770

Asymmetrical flight feathers, with a narrow outer blade and broader inner blade, give birds better control in the air.

Many chicks are altricial – born in a helpless state. Blind and naked, they require prolonged parental care.

Elaborate nests are built by the male weaver bird to impress prospective mates, testament to the brain power of birds.

DEBATE

ARE BIRDS DINOSAURS?

Traditionally birds are in a class separate from reptiles, including dinosaurs. But today scientists hold that all descendants of a common ancestor should be classified together to reflect evolutionary relationships – a method known as cladistics. This makes birds as much a part of the dinosaur group as *Tyrannosaurus*.

Birds are the only living animals with feathers. They are warm-blooded vertebrates that stand on two legs and their forelimbs are considerably modified as wings. As well as facilitating flight, feathers insulate the body, so many birds stay active in icy-cold conditions, just like furry mammals. Feathers can also be colourful, showing that birds rely on flaunting visual cues to communicate and find a mate. Birds evolved from a group of two-legged, carnivorous dinosaurs that included *Tyrannosaurus*. It is possible – even likely – that these ancestors were already feathered.

TAKING TO THE AIR

No-one knows for sure how – or why – the first birds took to the air, but the fact that they did had effects that would be forever imprinted upon the bird's body. Their wristbones became fused together as arms evolved into wings. The breastbone evolved a huge keel for the attachment of larger muscles for powering the flapping wings. Already their dinosaur ancestors had air-filled, but strong bones. But birds coupled this with a strong cardiovascular system powered by a mammal-like four-chambered heart and a rapid metabolism to generate lots of energy. A system of air sacs – linked to the bone chambers – expanded their breathing capacity to flush stale air out of lungs more efficiently than in mammals.

Many reptilian features still remain. The bare parts of a bird's legs and toes have horny reptilian scales. Birds excrete a semi-solid waste product called uric acid (not a solution of urea, as in mammals). Waste from the kidneys and gut mix and exit via a common reptilian opening called a cloaca. But a bird's brain is better developed than that of a reptile, because it is supported by a warm-blooded body and fast metabolism. This makes birds not only skilled at flying, but remarkably sophisticated in the ways they acquire food or raise a family. Young birds hatch from reptilian hard-shelled eggs, but they are reared by intelligent parents who will invest much time and energy into raising them to maturity. Sixty million years of evolution mean that a bird is no longer just a reptile with feathers.

CROWNING GLORY >
Birds' remarkable colours and structures often appear over extravagant, such as this pigeon's elaborate head crest.

BIRD GROUPS

The 40 orders range from heavy-bodied ground-dwellers – a few of which are incapable of flight – to true masters of the air, such as soaring albatrosses, dive-bombing falcons, and hovering hummingbirds. They exploit habitats from deep sea to mountain peaks, from deserts to rainforests and wetlands.

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TINAMOUS

The ground-dwelling tinamous from Central and South America resemble Old World partridges, but they are most closely related to ratites.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	TINAMIFORMES
FAMILIES	1
SPECIES	47

Tinamous, the sole family in the order Tinamiformes, are small, ground-dwelling birds with a rounded body and short legs. All have a very short tail, which gives them a dumpy appearance, and some species are crested.

Unlike the ratites, tinamous have a ridged breastbone for the attachment of flight muscles, a feature that is seen in all other birds. Their wings are much better developed than those of the ratites, and they can fly, although only over short distances. Usually they are reluctant to take to the air and prefer instead to run away from predators. Tinamous have a comparatively small heart and lungs, which perhaps explains why these birds become exhausted so easily.

Some groups of tinamous inhabit woodlands and forest, while others are found in open grassland. All feed on seeds, fruit, insects, and sometimes small vertebrates. The cryptic plumage patterns of most species makes them difficult to spot in the wild. They are more likely to be recognized by their distinctive call.

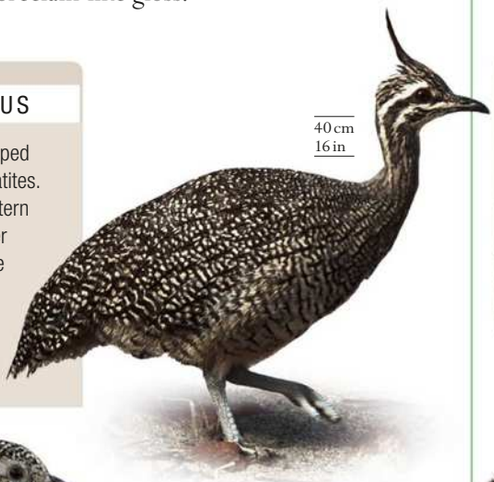
BEAUTIFUL EGGS

Male tinamous mate with many different females, and it is the males that tend the eggs and young. The nests are made in leaf litter on the ground. Tinamou eggs – brightly coloured turquoise, red, or purple – have a porcelain-like gloss.

DEBATE

ORIGINS OF TINAMOUS

Traditionally, tinamous are grouped separately from the flightless ratites. But the two groups share a pattern of skull bones not found in other birds, suggesting that they have a common ancestor. Scientists are not certain whether this ancestor was flightless or able to fly; the latter is more likely.



ELEGANT CRESTED TINAMOU
Eudromia elegans
F: Tinamidae
This bird of high-altitude shrubland occurs from S. Chile to Argentina. Unlike other tinamou species, it often lives in flocks.

ORNATE TINAMOU
Nothoprocta ornata
F: Tinamidae
An Andean tinamou, this species is found on the high montane grasslands of western S. America from Peru to N. Argentina.

RATITES

A group that includes the largest living birds, the ratites are flightless and strong footed. Some flock in open habitats; others live alone in forests.

PHYLUM	CHORDATA
CLASS	AVES
ORDERS	4
FAMILIES	4
SPECIES	13

Ratites evolved in the southern hemisphere and there is evidence to suggest they have flying ancestors. They lack some of the features associated with flight, but retain others. Ratites do not have the bony ridge on their breastbone that anchors powerful flight muscles in other birds, but they still have wings, and the part of the brain that controls flight is well developed.

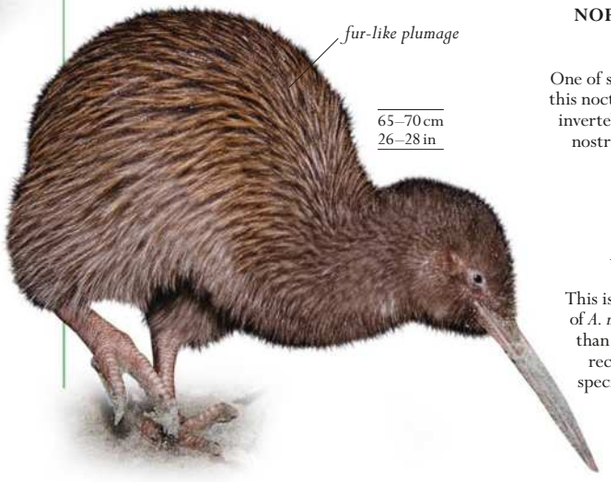
The ostriches, which make up the order Struthioniformes, are found in dry open areas in Africa. They are powerful-limbed birds that can run at high speed on flat ground. Somewhat similar in appearance, though less massively built, are the rheas – the order Rheiformes – from the grasslands of South America. Like most ratites, both these groups of birds have a reduced number of toes: the rhea has three toes, the ostrich only two. Both have large wings that they use in displays or to assist their balance when sprinting.

AUSTRALASIAN SPECIES

The Australasian ratites include the cassowaries and emus of the order Casuariiformes and the kiwis, the Apterygiformes. All are forest birds, save the emu, which inhabits scrubland and grassland. The tiny wings of these ratites are invisible under their plumage, which resembles shaggy hair rather than feathers. The nocturnal kiwis, familiar as the national symbol of New Zealand, are the only ratites that do not have a reduced number of toes.

The male ostrich scrapes out a shallow nest in the ground, in which his harem of females lay up to 50 eggs.

NORTH ISLAND KIWI
Apteryx mantelli
F: Apterygidae
One of several New Zealand kiwis, this nocturnal ratite detects buried invertebrate prey by smell, using nostrils at its probing bill tip.



TOKOEKA
Apteryx australis
F: Apterygidae
This is the South Island cousin of *A. mantelli*. Lighter coloured than its relative, it has been recognized as a separate species after DNA analysis.

SOUTHERN CASSOWARY
Casuarius casuarius
F: Casuariidae

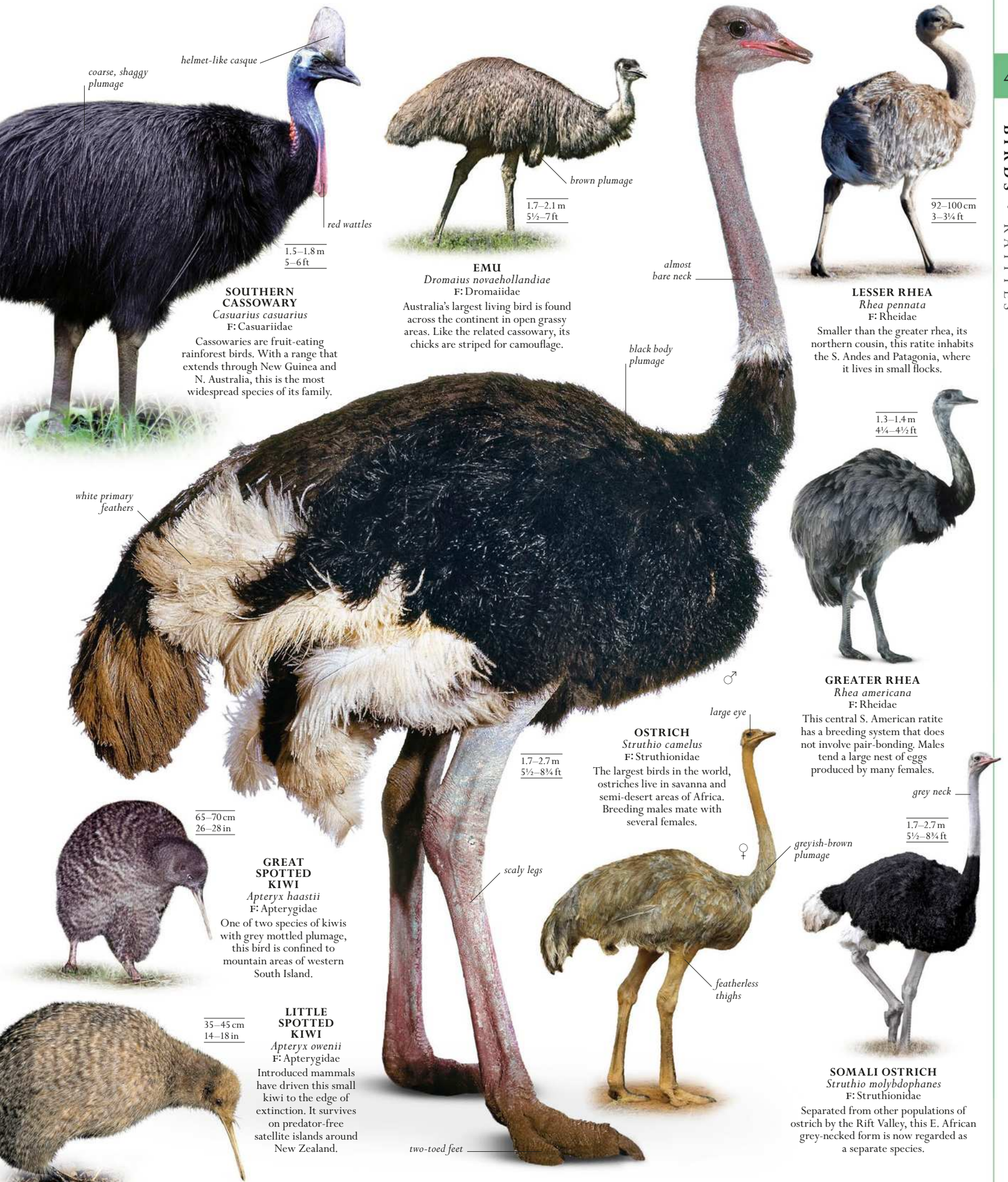
Cassowaries are fruit-eating rainforest birds. With a range that extends through New Guinea and N. Australia, this is the most widespread species of its family.

EMU
Dromaius novaehollandiae
F: Dromaiidae

Australia's largest living bird is found across the continent in open grassy areas. Like the related cassowary, its chicks are striped for camouflage.

LESSER RHEA
Rhea pennata
F: Rheidae

Smaller than the greater rhea, its northern cousin, this ratite inhabits the S. Andes and Patagonia, where it lives in small flocks.



OSTRICH
Struthio camelus
F: Struthionidae

The largest birds in the world, ostriches live in savanna and semi-desert areas of Africa. Breeding males mate with several females.

GREATER RHEA
Rhea americana
F: Rheidae

This central S. American ratite has a breeding system that does not involve pair-bonding. Males tend a large nest of eggs produced by many females.

GREAT SPOTTED KIWI
Apteryx haastii
F: Apterygidae

One of two species of kiwis with grey mottled plumage, this bird is confined to mountain areas of western South Island.

LITTLE SPOTTED KIWI
Apteryx owenii
F: Apterygidae

Introduced mammals have driven this small kiwi to the edge of extinction. It survives on predator-free satellite islands around New Zealand.

SOMALI OSTRICH
Struthio molybdophanes
F: Struthionidae

Separated from other populations of ostrich by the Rift Valley, this E. African grey-necked form is now regarded as a separate species.

FOWL, GAMEBIRDS, AND RELATIVES

Strong footed gamebirds are adapted to a wide range of habitats. They are primarily ground-dwellers and feed mostly on plants.

Although they may be good fliers, the majority of gamebirds, the order Galliformes, take to the air only when threatened. None, except the common and Japanese quails, sustains a long migratory flight. Most gamebirds spend their lives on the ground. Only the members of the curassow family of tropical America are habitual tree-dwellers; these birds make their nests in trees, too. Most primitive of the gamebird group are the big-footed megapodes of the Indo-Pacific forests. They bury their eggs in heaps of compost or in volcanic sand and rely on heat generated by decomposition or volcanic action to incubate them. All other gamebirds take a more active role in parenthood, although only the female raises the brood. The precocious offspring can run and feed soon after hatching.

Male gamebirds often have flamboyant plumage, which they use in courtship displays to attract a harem of females. Some species are armed with leg spurs to battle with competitors.

DOMESTICATED SPECIES

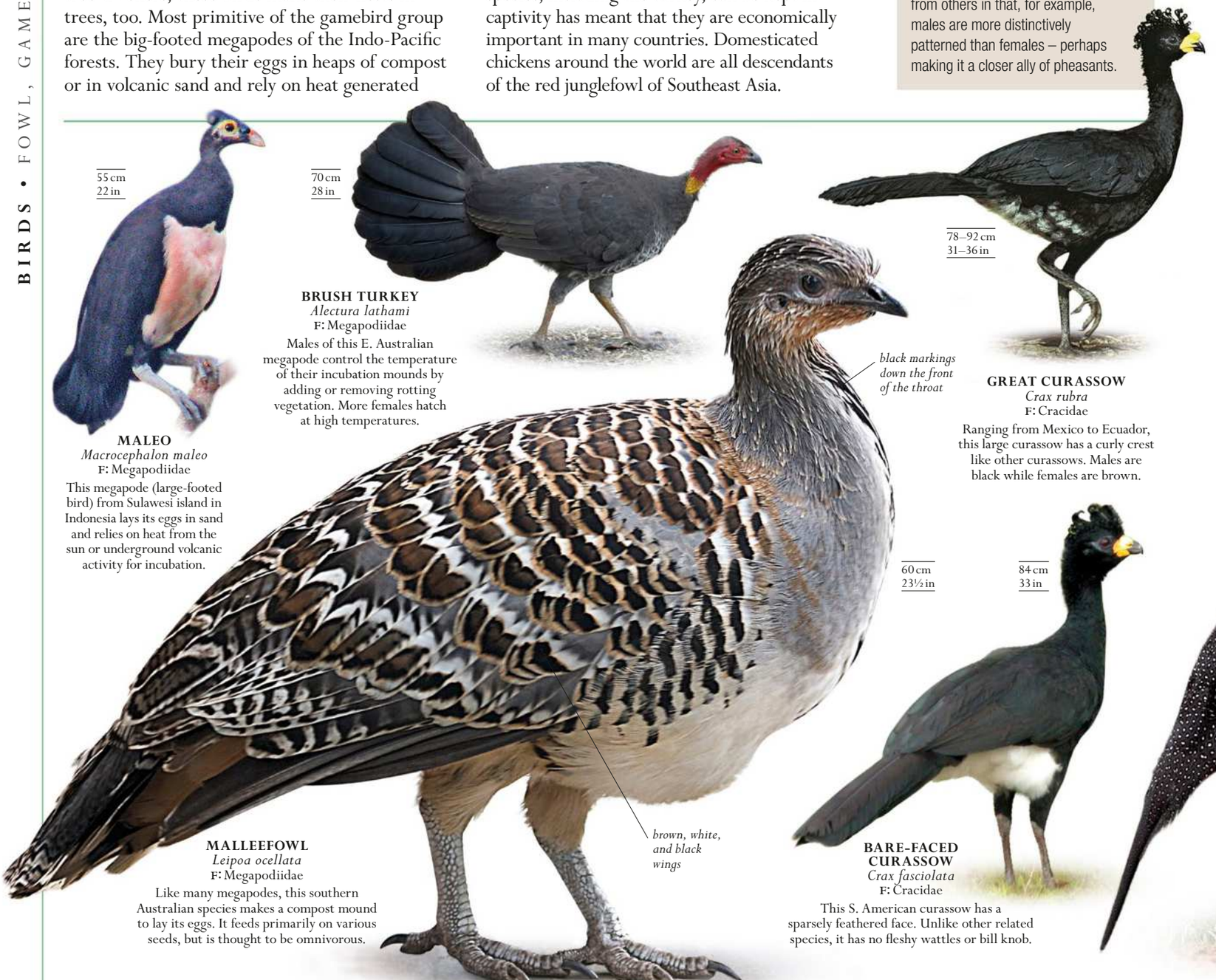
The relative ease with which many gamebird species, including the turkey, can be kept in captivity has meant that they are economically important in many countries. Domesticated chickens around the world are all descendants of the red junglefowl of Southeast Asia.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	GALLIFORMES
FAMILIES	5
SPECIES	300

DEBATE

WHAT IS A PARTRIDGE?

Traditional categories of birds may not reflect biological relationships. Many gamebirds are called partridges, but the European grey partridge differs subtly from others in that, for example, males are more distinctively patterned than females – perhaps making it a closer ally of pheasants.



MALEO
Macrocephalon maleo
F: Megapodiidae
This megapode (large-footed bird) from Sulawesi island in Indonesia lays its eggs in sand and relies on heat from the sun or underground volcanic activity for incubation.

BRUSH TURKEY
Alectura lathami
F: Megapodiidae
Males of this E. Australian megapode control the temperature of their incubation mounds by adding or removing rotting vegetation. More females hatch at high temperatures.

GREAT CURASSOW
Crax rubra
F: Cracidae
Ranging from Mexico to Ecuador, this large curassow has a curly crest like other curassows. Males are black while females are brown.

MALLEEFOWL
Leipoa ocellata
F: Megapodiidae
Like many megapodes, this southern Australian species makes a compost mound to lay its eggs. It feeds primarily on various seeds, but is thought to be omnivorous.

BARE-FACED CURASSOW
Crax fasciolata
F: Cracidae
This S. American curassow has a sparsely feathered face. Unlike other related species, it has no fleshy wattles or bill knob.

48–53 cm
19–21 in

PLAIN CHACHALACA
Ortalis vetula
F: Cracidae

Ranging from Texas to Costa Rica, this northernmost member of the American curassow family is the only one found in the USA.

46 cm
18 in

GREY-HEADED CHACHALACA
Ortalis cinereiceps
F: Cracidae

Named after their calls, chachalacas are brown-coloured relatives of curassows. This is a species of scrubby habitat from Honduras to Colombia.

69 cm
27 in

BLUE-THROATED PIPING GUAN
Pipile cumanensis
F: Cracidae

This S. American bird has glossy black plumage typical of tree-dwelling piping guans. They are named for their shrill breeding call.

59–65 cm
23–26 in

HIGHLAND GUAN
Penelopina nigra
F: Cracidae

This C. American bird is more ground dwelling than other guans. It is perhaps the only member of its family to nest on the ground.

66–76 cm
26–30 in

SPIX'S GUAN
Penelope jacquacu
F: Cracidae

This S. American species belongs to a group of brown guans that resemble chachalacas, but have shorter legs. It nests in trees and has a loud mating call.

55 cm
22 in

BEARDED GUAN
Penelope barbata
F: Cracidae

Named for its streaked neck, the bearded guan, like related species in this genus, is a rainforest bird. It is found in Ecuador and Peru.

67–75 cm
26–30 in

CHESTNUT-BELLIED GUAN
Penelope ochrogaster
F: Cracidae

The throat wattle that is typical of brown guans is especially well developed in this species from south-central Brazil.

76 cm
30 in

CAUCA GUAN
Penelope perspicax
F: Cracidae

A bronze-sheened relative of the spix's guan, this bird is found only in the Cauca Valley region in the western and northern parts of Colombia.

68–75 cm
27–30 in

DUSKY-LEGGED GUAN
Penelope obscura
F: Cracidae

The only brown guan with dark rather than reddish legs, this species occurs in central S. America, from Brazil to northern Argentina.

61–71 cm
24–28 in

VULTURINE GUINEAFOWL
Acryllium vulturinum
F: Numididae

Guineafowl are African gamebirds that live in groups, but are monogamous. They all have a bare head. This is the largest species of guineafowl and is found in E. Africa.

26–31 cm
10–12 in

MOUNTAIN QUAIL
Oreortyx pictus
F: Odontophoridae

This native of the Rocky Mountains, like other American quails, is a ground-nesting, monogamous species.

24–27 cm
9½–10½ in

CALIFORNIAN QUAIL
Callipepla californica
F: Odontophoridae

Found from Oregon to California, this species is characterized by its forward-drooping crest, comprised of a cluster of six feathers.

25 cm
10 in

GAMBEL'S QUAIL
Callipepla gambelii
F: Odontophoridae

This relative of the Californian quail has a longer crest. It occurs in the desert in the south of California and the ranges of the two do not overlap.

»

» FOWL, GAMEBIRDS, AND RELATIVES

CHUKAR PARTRIDGE
Alectoris chukar
F: Phasianidae

With a range extending across central Eurasia, this is the most widespread of the red-legged partridges – typically birds of dry country, with striking black markings.

ARABIAN PARTRIDGE
Alectoris melanocephala
F: Phasianidae

This large red-legged partridge occurs in semi-desert regions of the Arabian Peninsula and Yemen. Its preferred habitat is juniper woodland.

CHESTNUT-BELLIED HILL PARTRIDGE
Arborophila javanica
F: Phasianidae

Found in S.E. Asian rainforests, hill partridges are small, cryptically coloured gamebirds with stumpy tails. Many, such as this Javan species, have distinctive head markings.

GREY PARTRIDGE
Perdix perdix
F: Phasianidae

This is the most widespread of a small genus of dark-bellied Eurasian gamebirds that are more related to pheasants than other partridges.

GREY FRANCOLIN
Francolinus pondicerianus
F: Phasianidae

As with related junglefowl, males of this S. Asian francolin have leg spurs that they use in fighting.

RED-NECKED FRANCOLIN
Francolinus afer
F: Phasianidae

A ground-nesting bird of forest and grassland, this species is widespread through Africa, from the Democratic Republic of Congo to the Cape.

ROULROUL
Rollulus rouloul
F: Phasianidae

Related to hill partridges, the S.E. Asian roulroul has a more colourful plumage. Males are dark blue and have a reddish crest; females are green and lack the crest.

CHINESE BAMBOO PARTRIDGE
Bambusicola thoracicus
F: Phasianidae

There are two species of bamboo partridge, birds of E. Asia that are related to francolins and junglefowl. This bird is native to China.

COMMON QUAIL
Coturnix coturnix
F: Phasianidae

Unusually for a gamebird, this tiny species of W. Eurasian grasslands and semi-desert is migratory in the northern parts of its range.

SPRUCE GROUSE
Canachites canadensis
F: Phasianidae

Like other woodland grouse, this N. American species can digest the needles of conifer and spruce trees, rejected by most animals.

SOOTY GROUSE
Dendragapus fuliginosus
F: Phasianidae

One of several N. American grouse that have an inflatable neck sac, this dark-coloured species inhabits the pine forests of the Pacific coast.

SHARP-TAILED GROUSE
Tympanuchus phasianellus
F: Phasianidae

This N. American grouse is a more widespread, more northerly cousin of prairie chickens. Males have purple sacs for display.

GREATER PRAIRIE CHICKEN
Tympanuchus cupido
F: Phasianidae

This species is from the C. USA. As with other species of prairie chicken, males engage in group courtship displays by inflating their coloured neck sac.

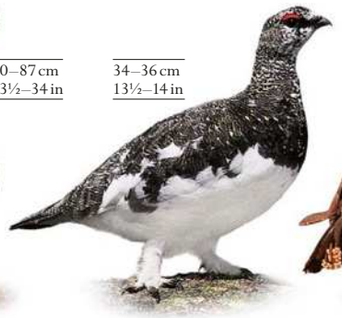
LESSER PRAIRIE CHICKEN
Tympanuchus pallidicinctus
F: Phasianidae

Found in southern N. America, this small species of prairie chicken has a coloured neck sac and drumming call, typical of *Tympanuchus* grouse.

60–87 cm
23½–34 in

WESTERN CAPERCAILLIE
Tetrao urogallus
F: Phasianidae

Found in western Eurasian coniferous forests, this is the largest member of the grouse family. Males display to females with rattling, popping calls.



34–36 cm
13½–14 in

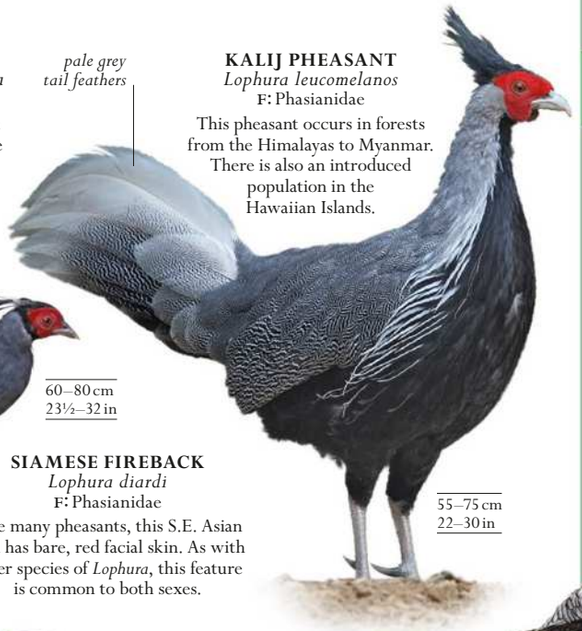
ROCK PTARMIGAN
Lagopus muta
F: Phasianidae

One of three related grouse that turn white in winter, the rock ptarmigan is a tundra and mountain bird with a circumpolar distribution.

38–41 cm
15–16 in

RED GROUSE
Lagopus lagopus scotica
F: Phasianidae

Unlike most ptarmigan species, this British race of the widespread circumpolar willow grouse does not turn white in winter.

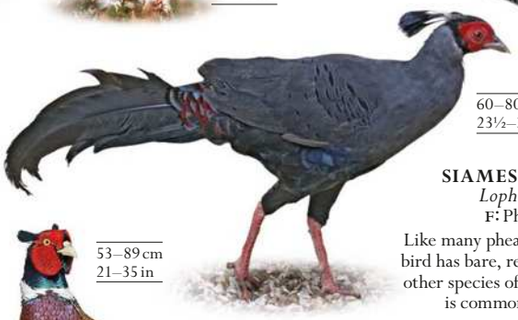


pale grey tail feathers

KALIJ PHEASANT
Lophura leucomelanos
F: Phasianidae

This pheasant occurs in forests from the Himalayas to Myanmar. There is also an introduced population in the Hawaiian Islands.

55–75 cm
22–30 in



60–80 cm
23½–32 in

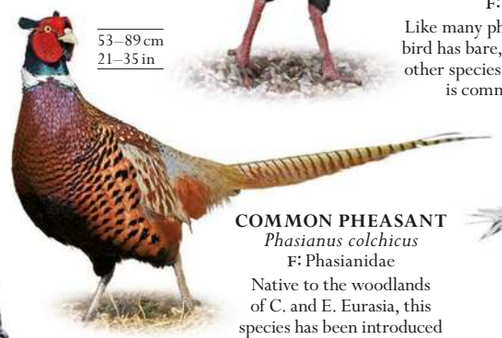
SIAMESE FIREBACK
Lophura diardi
F: Phasianidae

Like many pheasants, this S.E. Asian bird has bare, red facial skin. As with other species of *Lophura*, this feature is common to both sexes.

60–70 cm
23½–28 in

SATYR TRAGOPAN
Tragopan satyra
F: Phasianidae

This is a Himalayan species of *Tragopan*, a genus of Asian tree-nesting pheasants. Male tragopans have an expandable fleshy lappet and horns that are used for display.



53–89 cm
21–35 in

COMMON PHEASANT
Phasianus colchicus
F: Phasianidae

Native to the woodlands of C. and E. Eurasia, this species has been introduced into western Europe, where it is now common in farmland.

60–120 cm
23½–47 in

LADY AMHERST'S PHEASANT
Chrysolophus amherstiae
F: Phasianidae

Like many other pheasants, only males of this species have spectacular plumage, and only females care for the young. This bird is from China and Myanmar.

40–50 cm
16–20 in

PALAWAN PEACOCK-PHEASANT
Polyplectron napoleonis
F: Phasianidae

Male peacock-pheasants lack the long plumes of their peafowl relatives, but display tail feathers marked with iridescent eyespots.

0.8–2.2 m
2½–7¼ ft

INDIAN PEAFOWL
Pavo cristatus
F: Phasianidae

This tropical Asian species occurs in India and Sri Lanka. Males court females by raising their long plumes, which are just above the tail.

white-tipped tail fanned in display

bald head

1.1–1.2 m
3½–4 ft

WILD TURKEY
Meleagris gallopavo
F: Phasianidae

Turkeys are large, wattled gamebirds native to N. America. This species from the S. USA is the ancestor of domesticated turkeys.

41–78 cm
16–31 in

RED JUNGLEFOWL
Gallus gallus
F: Phasianidae

Unlike related francolins, males of this Asian ancestor of domestic chickens mate with many females. They have a comb and wattles, which are absent in females.

WATERFOWL

Species in this group are web-footed birds adapted for surface swimming. The majority feed on plants, although some take small aquatic animals.

Most waterfowl have short legs set well back on the body. These birds, the Anseriformes, swim by propelling themselves with webbed feet, and all have plumage kept waterproofed with oil taken from a gland near the tail. South American screamers and the magpie-goose from Australasia have partially webbed feet, spending much of their time on land or wading in marshes. These birds belong to two ancient families. All other waterfowl are classified in a single family, the most primitive group being the whistling ducks.

SWANS, GEESE, AND DUCKS

In swans and geese, the sexes have similar plumage patterns. These long-necked, long-winged birds occur mostly outside the tropics. Many northern species breed close to the Arctic and migrate southwards to overwinter. Ducks are generally smaller and have a shorter neck than others in the Anatidae family.

Unlike geese and swans, male ducks are usually more brightly plumaged than the females, especially when breeding. Both sexes of many duck species have a vividly coloured wing-patch called a speculum.

The typical "duckbills" of waterfowl have internal plates that have evolved to strain aquatic food drawn in by a muscular tongue. All species retain this feature, even though some have adopted different feeding methods. Geese graze on grasslands, but swans are more aquatic and use their long neck to plunge their head deep in water. Many ducks dabble – up-ending to feed on or just below the water surface. Others, such as pochards, dive under water to gather food. The saw-billed ducks have a narrow bill with serrated edges to catch fish. One group of ducks, including eiders, scoters, and mergansers, includes accomplished sea divers.

NESTING

Most waterfowl are monogamous, some pairing for life. They nest largely on the ground, but a few nest in trees. The marine ducks come inland to breed. All waterfowl produce downy chicks that can walk and swim soon after hatching.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	ANSERIFORMES
FAMILIES	3
SPECIES	177

Flying in formation reduces air drag, enabling birds like these snow geese to conserve energy on long migrations.

53–56 cm
21–22 in

RED-BREASTED GOOSE
Branta ruficollis
F: Anatidae

This is the most brightly coloured member of the *Branta* group of dark geese. It breeds in northwestern Siberia, where it nests close to raptors, possibly for protection from foxes.

striking red, black, and white plumage

50–110 cm
20–43 in

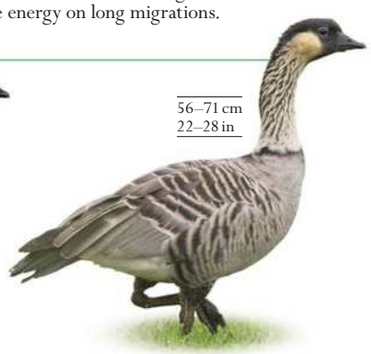
CANADA GOOSE
Branta canadensis
F: Anatidae

The largest of the *Branta* geese, this species is native to N. America, but has been introduced to northern Europe.

58–71 cm
23–28 in

BARNACLE GOOSE
Branta leucopsis
F: Anatidae

This goose breeds on Arctic tundra in Greenland and Russia, where it avoids predators by nesting on cliff tops.



56–71 cm
22–28 in

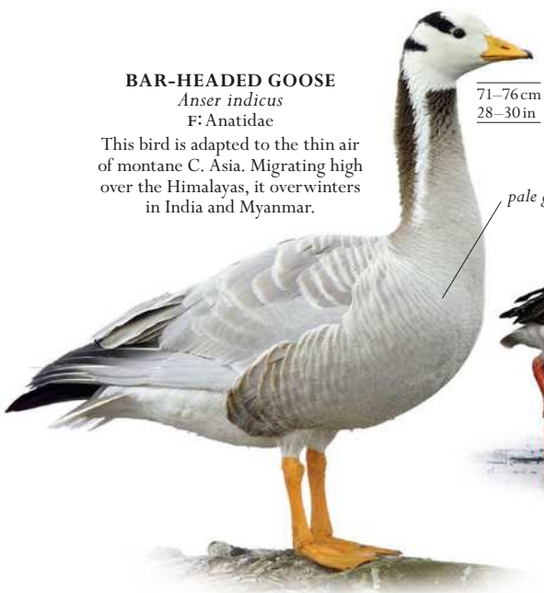
HAWAIIAN GOOSE
Branta sandvicensis
F: Anatidae

Confined to the Hawaiian Islands, this goose has reduced foot-webbing and strong claws, and is adapted to climbing on to rocky lava flows.

60–75 cm
23½–30 in

PINK-FOOTED GOOSE
Anser brachyrhynchus
F: Anatidae

This small, grey goose breeds on rocky outcrops of tundra in Greenland and Iceland, and overwinters in western Europe.



71–76 cm
28–30 in

BAR-HEADED GOOSE
Anser indicus
F: Anatidae

This bird is adapted to the thin air of montane C. Asia. Migrating high over the Himalayas, it overwinters in India and Myanmar.

pale grey body

76–89 cm
30–35 in

GREYLAG GOOSE
Anser anser
F: Anatidae

Widespread across the grasslands and wetlands in Eurasia, this typical grey *Anser* goose is the wild ancestor of domesticated geese.

EMPEROR GOOSE
Anser canagicus
F: Anatidae

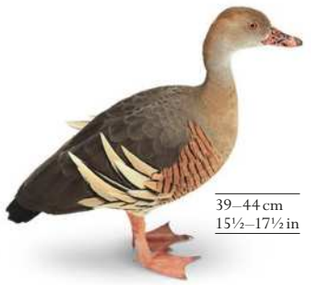
Found in northeastern Siberia and Alaska, this goose grazes on coastal grass and seaweed. It is less gregarious than most other geese.

ASHY-HEADED GOOSE
Chloephaga poliocephala
F: Anatidae

S. American *Chloephaga* geese are perhaps more related to ducks than to other geese. This species occurs in Chile and Argentina. Like others in its genus, it may perch in trees.

EGYPTIAN GOOSE
Alopochen aegyptiaca
F: Anatidae

Belonging to a group of southern hemisphere geese that are related to ducks, the Egyptian goose is widespread through Africa.



PLUMED WHISTLING DUCK
Dendrocygna eytoni
F: Anatidae

Distinct from geese and true ducks, whistling ducks are named for their unique call. This is an Australian species.

MAGPIE-GOOSE
Anseranas semipalmata
F: Anseranatidae

From Australian wetlands, this species has long legs and partially webbed feet. It is not closely related to any other waterfowl.

CAPE BARREN GOOSE
Cereopsis novaehollandiae
F: Anatidae

This distinctive goose is restricted to southern Australia and offshore islands, where it gathers in small flocks and grazes on grassland.

BLUE-WINGED GOOSE
Cyanochen cyanoptera
F: Anatidae

This goose has a thick plumage as an adaptation to the cool highlands of its native Eritrea and Ethiopia.

COSCOROBA SWAN
Coscoroba coscoroba
F: Anatidae

Resembling a goose, this is the smallest of swans. It is confined to swamps in the southern parts of Chile and Argentina.

MUTE SWAN
Cygnus olor
F: Anatidae

This species breeds in Europe and C. Asia. Like other swans, it grazes on underwater vegetation by submerging its head.

BLACK SWAN
Cygnus atratus
F: Anatidae

This sooty-black swan with white wing tips may nest in huge colonies. Native to Australia and Tasmania, it has been introduced to New Zealand, Europe, and N. America.

TRUMPETER SWAN
Cygnus buccinator
F: Anatidae

Related to other vocal swans, such as the Eurasian whooper swan (*C. cygnus*), this N. American species has a loud, honking call.

BLACK-NECKED SWAN
Cygnus melancoryphus
F: Anatidae

Found in southern S. America, this species spends more time on water than other swans and nests on floating vegetation.

WHITE-BACKED DUCK
Thalassornis leuconotos
F: Anatidae

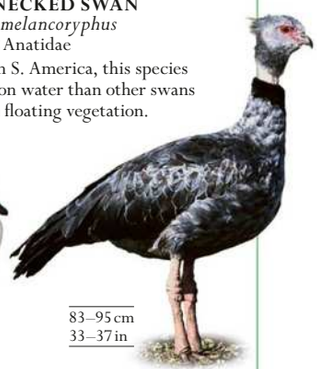
This bird from Africa and Madagascar is related to whistling ducks, but spends more time on water, nesting on islands of vegetation.

AFRICAN PYGMY-GOOSE
Nettapus auritus
F: Anatidae

Like other pygmy-geese, this African species nests in tree hollows. It is usually found in wetlands with water lilies, on which it feeds.

ORINOCO GOOSE
Neochen jubata
F: Anatidae

A S. American relative of ducks, this goose occurs on tropical wet savanna and forest edges along rivers.



SOUTHERN SCREAMER
Chauna torquata
F: Anhimidae

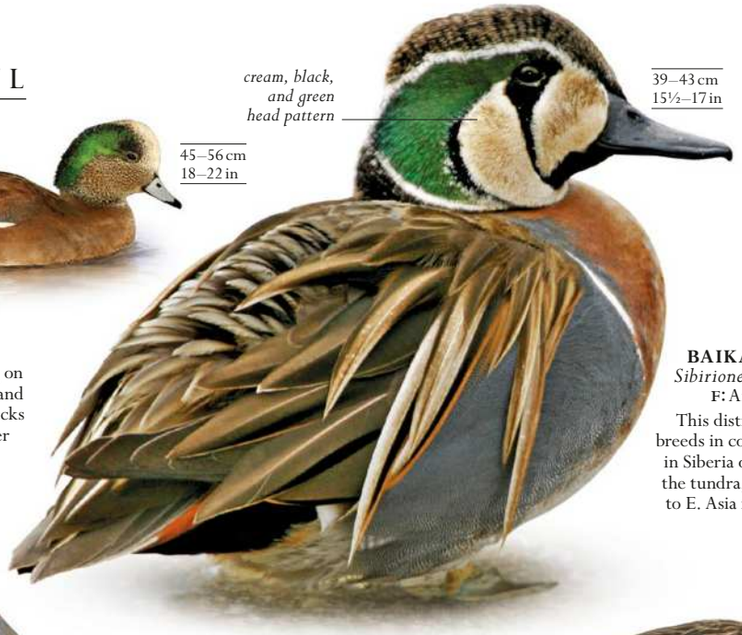
Screamers are large, bulky birds that live in S. American marshlands. Like other screamers, this species has bony wing spurs that may be used in fighting.

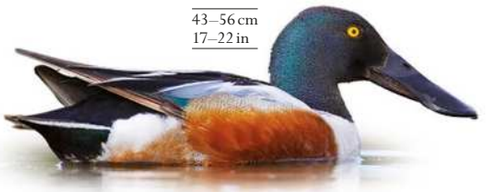
»

» WATERFOWL

45–56 cm
18–22 in

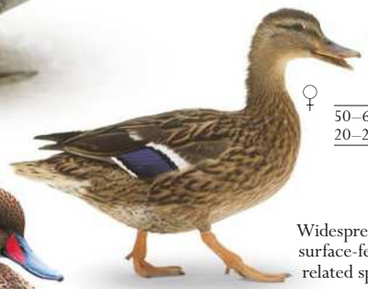
AMERICAN WIGEON
Mareca americana
F: Anatidae
This species feeds by dabbling on the surface of shallow waters and occasionally up-ends. Huge flocks winter in the Caribbean after breeding in N. America.


cream, black, and green head pattern
39–43 cm
15½–17 in


43–56 cm
17–22 in

NORTHERN SHOVELER
Spatula clypeata
F: Anatidae
Both sexes of dabbling (surface-feeding) ducks typically have a coloured wing-patch called a speculum. This widespread wetland species of the northern hemisphere has a green speculum.

BAIKAL TEAL
Sibirionetta formosa
F: Anatidae
This distinctive duck breeds in cold, open forest in Siberia on the edge of the tundra, and migrates to E. Asia in the winter.


♀
50–65 cm
20–26 in

♂

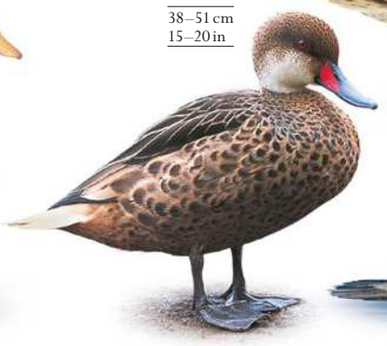
MALLARD
Anas platyrhynchos
F: Anatidae
Widespread in the northern hemisphere, the surface-feeding mallard can interbreed with related species, perhaps indicating that this group has only recently evolved.

55–65 cm
22–26 in

INDIAN RUNNER
Anas platyrhynchos
F: Anatidae
A domestic descendant of the wild mallard, this long-necked breed originated in the Malay Peninsula and India in the 19th century.

50–65 cm
20–26 in

DOMESTIC DUCK
Anas platyrhynchos
F: Anatidae
Most domesticated ducks have descended from the mallard. They are raised for their meat, eggs, or down, or kept for ornamental purposes.


38–51 cm
15–20 in

WHITE-CHEEKED PINTAIL
Anas bahamensis
F: Anatidae
This saltwater dabbling duck is found in S. American estuaries and mangrove swamps. Unlike temperate northern pintails, both sexes look alike.

33–40 cm
13–16 in

BUFFLEHEAD
Bucephala albeola
F: Anatidae
The smallest sea duck in N. America, the bufflehead nests in tree-holes and sometimes uses those vacated by woodpeckers.

38–51 cm
15–20 in

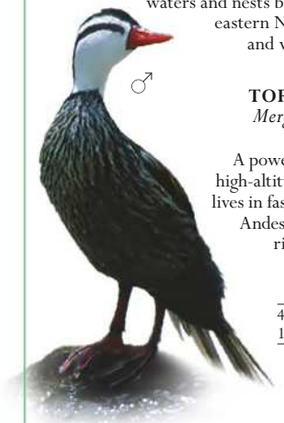
HARLEQUIN DUCK
Histrionicus histrionicus
F: Anatidae
A highly buoyant sea duck, this species rides choppy waters and nests beside fast-flowing streams in eastern N. America, Iceland, and western Russia.

43–51 cm
17–20 in

WOOD DUCK
Aix sponsa
F: Anatidae
The newly hatched chicks of this N. American tree-perching duck jump down from their nests in high tree-holes to reach the water below.

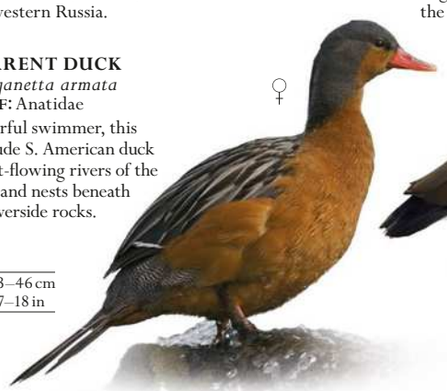
orange cheek plumes
41–51 cm
16–20 in

MANDARIN DUCK
Aix galericulata
F: Anatidae
Wrongly thought to be monogamous, this tree-nesting duck is a symbol of love in its native northeastern Asia. It has been introduced in Europe and California.


♂

TORRENT DUCK
Merganetta armata
F: Anatidae
A powerful swimmer, this high-altitude S. American duck lives in fast-flowing rivers of the Andes and nests beneath riverside rocks.

43–46 cm
17–18 in


♀

35–38 cm
14–15 in

RINGED TEAL
Callonetta leucophrys
F: Anatidae
Like other tropical ducks, this S. American teal is not migratory and retains its plumage colours throughout the year.

white flank patch

SURF SCOTER
Melanitta perspicillata
F: Anatidae

The N. American surf scoter, like other scoter species, breeds near fresh water and winters at sea. The male's body is entirely black.

HOODED MERGANSER
Lophodytes cucullatus
F: Anatidae

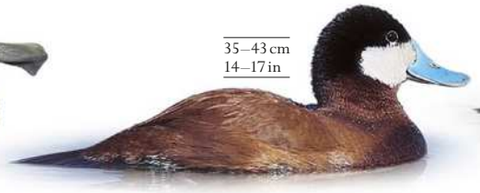
Found in N. America, this bird has a saw-edged bill for catching fish. It dives with powerful kicks of the feet.

BRONZE-WINGED DUCK
Speculanas specularis
F: Anatidae

This duck is found along the rivers of S. America. It is locally called "dog-duck" after the barking call of the female.

PINK-EARED DUCK
Malacorhynchus membranaceus
F: Anatidae

The pink head spot of this widespread Australian species is less distinctive than its zebra pattern. It consumes plankton, strained from water by beak flaps.



RUDDY DUCK
Oxyura jamaicensis
F: Anatidae

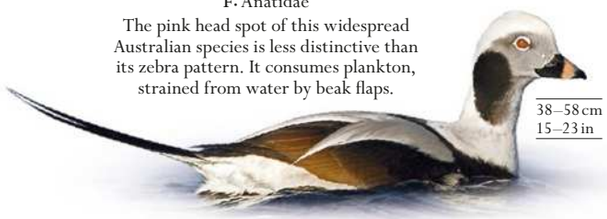
This N. American duck, now introduced in Europe, has a stiff tail which it uses as a rudder when diving.

TUFTED DUCK
Aythya fuligula
F: Anatidae

A Eurasian member of the pochard group, the tufted duck feeds mostly, though not entirely, on invertebrates in contrast to its largely vegetarian relatives.

CANVASBACK
Aythya valisineria
F: Anatidae

This N. American bird is the largest species of pochard, a group of ducks with typically stocky bodies and large heads.



LONG-TAILED DUCK
Clangula hyemalis
F: Anatidae

Unlike most other Arctic sea ducks, the long-tailed duck breeds in saltwater as well as freshwater habitats. Males have a distinctive long tail.

SMEW
Mergellus albellus
F: Anatidae

A member of the group of cavity-nesting mergansers, this species is the only small white duck found in northern Eurasia.

COMMON SHELDUCK
Tadorna tadorna
F: Anatidae

This goose-like duck is largely a coastal resident in Europe, but in Asia it migrates southwards from inland regions during winter. It nests in burrows.

RED-BREASTED MERGANSER
Mergus serrator
F: Anatidae

Widespread across the northern hemisphere, the red-breasted merganser breeds on coasts and spends more time at sea than other mergansers.

KING EIDER
Somateria spectabilis
F: Anatidae

This bird breeds along Arctic tundra coastlines. Its large body size may help it to dive deeply for invertebrate prey.

ROSYBILL
Netta peposaca
F: Anatidae

This S. American duck is related to the diving pochards, but spends more time feeding at the water surface. Only the males have a red bill.

CRESTED DUCK
Lophonetta specularioides
F: Anatidae

This Andean species is a possible relic of a S. American lineage that was ancestral to more widespread dabbling ducks, such as the mallard.

STELLER'S EIDER
Polysticta stelleri
F: Anatidae

Like other related sea ducks of Arctic and subarctic regions, this eider overwinters further south in huge flocks, sometimes numbering 20,000 birds.

PENGUINS

With their two-toned plumage, erect posture, and waddling walk, penguins are instantly recognizable as the classic symbol of the southern oceans.

Residents of the coastal regions of the southern hemisphere, all penguins are adapted to life in cold water. Most species live around islands encircling Antarctica, although some are found on southern coastlines of South America, Africa, and Australasia.

These flightless birds of the order Sphenisciformes probably descended from a common ancestor shared with the albatrosses. They may also be distant cousins of the divers from the northern hemisphere.

SPECIAL ADAPTATIONS

Penguins have legs set far back towards the tail, a feature that provides excellent propulsion in water and is seen also in birds such as divers and grebes. On land penguins walk upright, but with webbed feet placed flat on the ground their gait is ungainly. In common with other flightless birds, penguins have reduced wings, but these are modified in such a way that they can be used as flippers. In effect, penguins "fly" under water.

A penguin's short, densely packed feathers have downy bases that trap warm air, and a layer of fat beneath the skin provides further insulation. The feather tips are greasy and waterproof, lubricated by oil produced from a large gland on the rump. A complex system of blood-flow through the legs and feet ensures that the penguin's body is not chilled by standing on snow or ice. The largest penguin species incubate their eggs on their feet. All penguins have counter-shaded plumage (dark above and pale below), which in the sea provides camouflage against ocean-going predators, such as leopard seals.

FORAGING AND NESTING

Penguins can dive for fish, shrimp, and krill more than 200 times each day. When they have eggs to incubate and young to tend, the parents take it in turns to forage. In the case of emperor penguins, one of the few species to breed on the Antarctic pack ice, the males incubate the eggs alone throughout the winter while the females remain feeding at sea. Most penguins are colonial breeders and often return to the same nest site each season.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	SPHENISCIFORMES
FAMILIES	1
SPECIES	18

DEBATE
FLYING ANCESTORS?

In the early 20th century, flightless birds were popularly believed to be primitive. It was hoped that study of their embryos would reveal evidence of a direct link to a dinosaurian past. Penguin eggs became sought after, and members of Robert Falcon Scott's last expedition (1910–13) made a courageous journey to an emperor rookery in the bleak Antarctic winter. By the time the eggs they collected received scientific attention, the embryo theory had been disproved. Modern studies of anatomy, fossils, and DNA show that the ancestors of penguins, and other flightless birds, could fly.

KING PENGUIN
Aptenodytes patagonicus
F: Spheniscidae
Resembling the emperor penguin, this sub-Antarctic species has an orange-yellow neck and breast markings, and incubates a single egg on its feet.
90–100 cm
3–3¼ ft

EMPEROR PENGUIN
Aptenodytes forsteri
F: Spheniscidae
The largest penguin, this species breeds in colonies on Antarctic ice. Males incubate eggs during the bitter polar winter.
1.1–1.2 m
3½–4 ft

white feathers contrast with black head and wings

ROCKHOPPER PENGUIN
Eudyptes chrysocome
F: Spheniscidae
The smallest of the sub-Antarctic crested penguins, this bird gets its name from its habit of clambering over rocks and boulders.
55–60 cm
22–23½ in

yellow plume

MACARONI PENGUIN
Eudyptes chrysolophus
F: Spheniscidae
This bird inhabits islands in the far southern Atlantic and Indian oceans but is the only crested penguin to breed on the Antarctic Peninsula.
70 cm
28 in

FIORDLAND PENGUIN
Eudyptes pachyrhynchus
F: Spheniscidae
Nesting in the cool coastal forests of S. New Zealand, this species has hair-like crest feathers and a red bill typical of *Eudyptes* penguins.
45–58 cm
18–23 in

LITTLE PENGUIN
Eudyptula minor
F: Spheniscidae
A burrow-nester, this bird is the smallest of all penguins. It occurs along the coasts of S. Australia and New Zealand.
35–40 cm
14–16 in

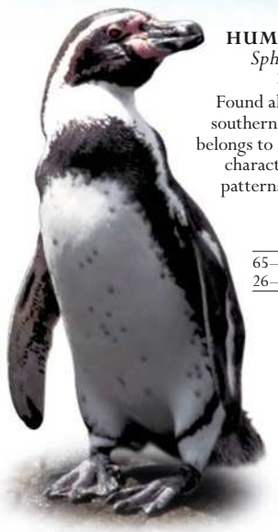
ADELIE PENGUIN
Pygoscelis adeliae
F: Spheniscidae
One of three "brush-tailed" *Pygoscelis* penguins from Antarctica and adjacent islands, the Adelie penguin breeds in colonies of more than 200,000 pairs.

GENTOO PENGUIN
Pygoscelis papua
F: Spheniscidae
This penguin breeds on the Antarctic Peninsula and Southern Ocean islands. Its nest is a simple cluster of sticks, stones, and feathers.

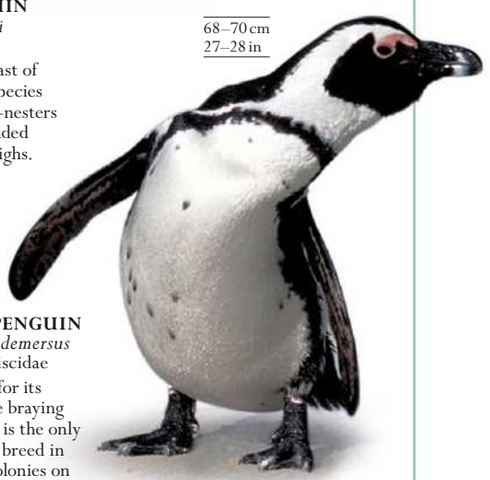
YELLOW-EYED PENGUIN
Megadyptes antipodes
F: Spheniscidae
A cousin of *Eudyptes* crested penguins, this rare New Zealand bird nests in scrub, but not in dense colonies like the other *Eudyptes* penguins.

GALAPAGOS PENGUIN
Spheniscus mendiculus
F: Spheniscidae
This is the only penguin to breed in tropical waters cooled by the Humboldt Current, which flows along the western coast of S. America. It nests in rock crevices.

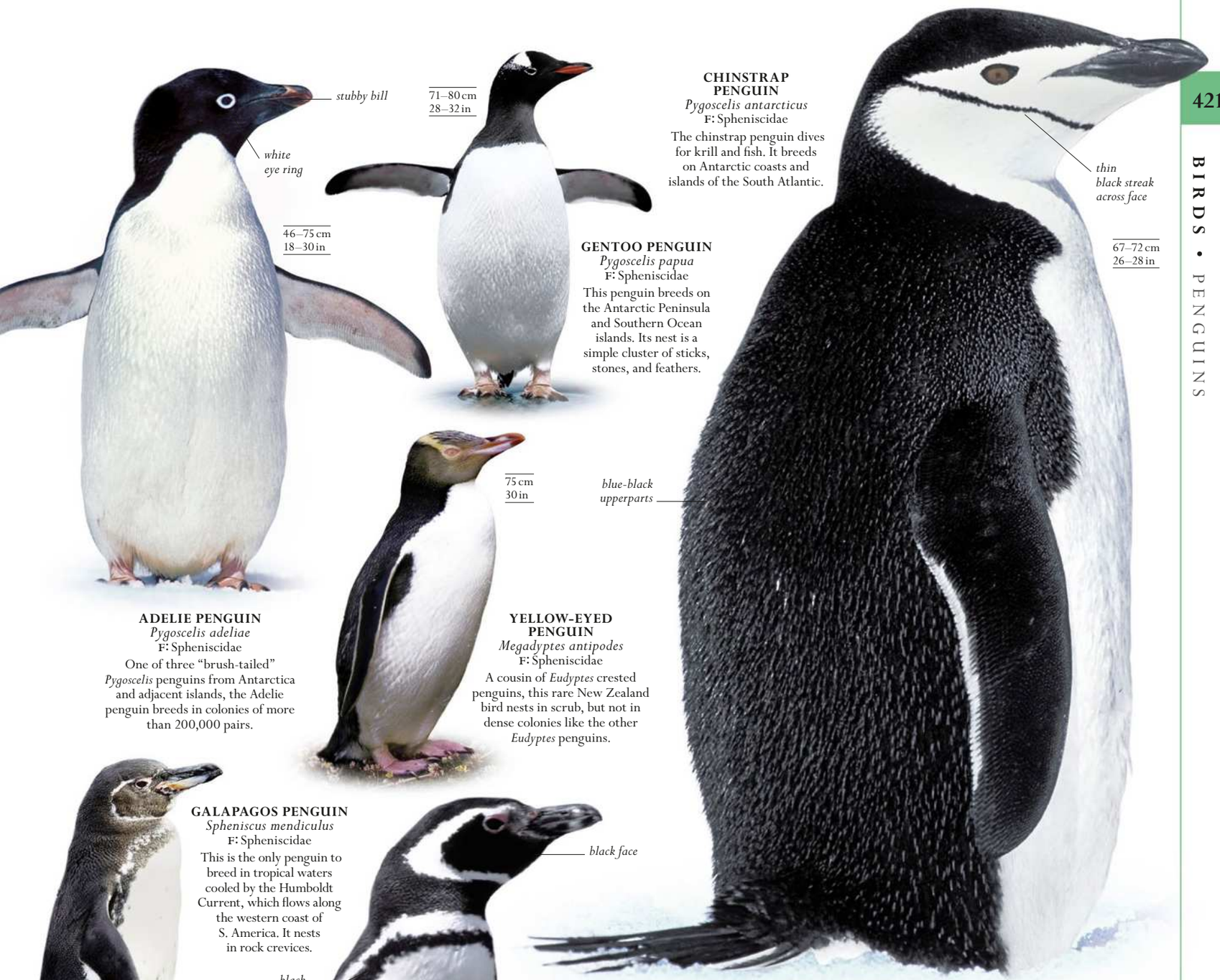
MAGELLANIC PENGUIN
Spheniscus magellanicus
F: Spheniscidae
Closely related to the Humboldt penguin, this banded penguin lives in colonies around the southern tip of S. America and the Falkland Islands.



HUMBOLDT PENGUIN
Spheniscus humboldti
F: Spheniscidae
Found along the Pacific coast of southern S. America, this species belongs to a group of burrow-nesters characterized by bold banded patterns from flanks to thighs.



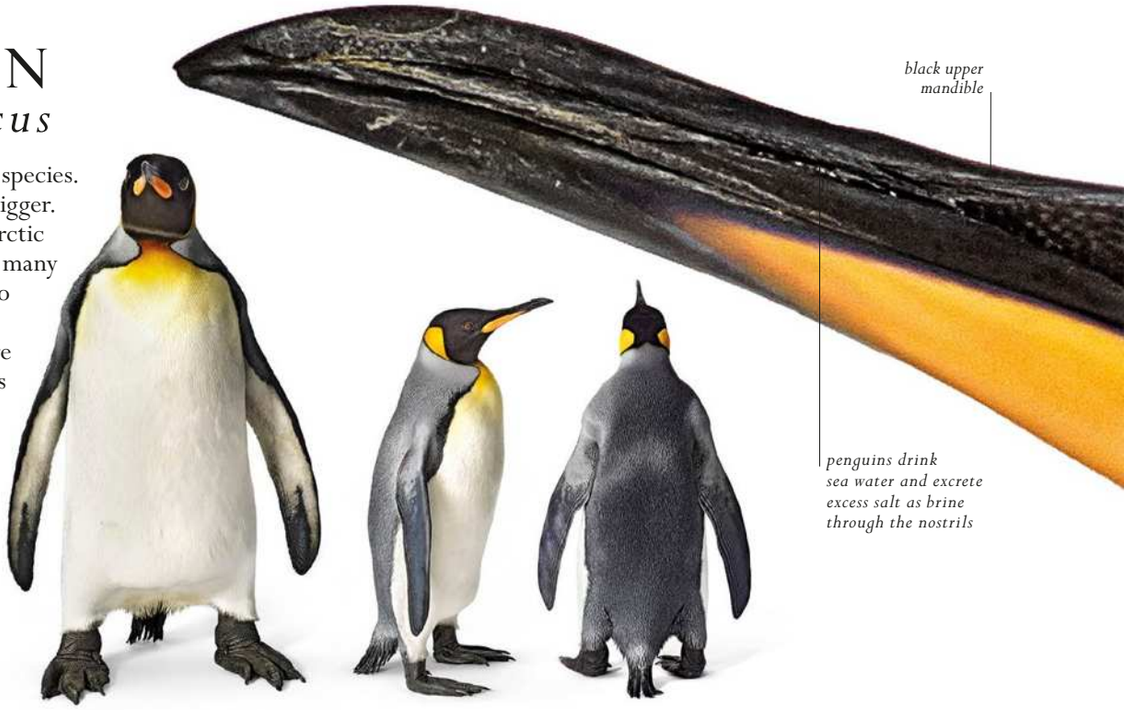
JACKASS PENGUIN
Spheniscus demersus
F: Spheniscidae
Named for its donkey-like braying call, this bird is the only penguin to breed in Africa, in colonies on southwestern coasts.



CHINSTRAP PENGUIN
Pygoscelis antarcticus
F: Spheniscidae
The chinstrap penguin dives for krill and fish. It breeds on Antarctic coasts and islands of the South Atlantic.

KING PENGUIN
Aptenodytes patagonicus

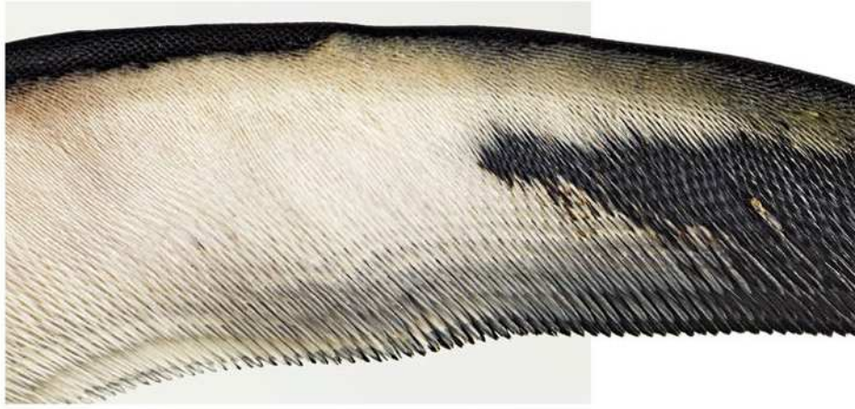
The king penguin is the second largest penguin species. Only its close cousin, the emperor penguin, is bigger. Unlike the emperor, the king inhabits sub-Antarctic islands. It hunts fish, ignoring the krill taken by many of its rivals, and dives to extraordinary depths to get them – sometimes to over 200 m (660 ft). It produces just one egg at a time and it takes more than a year to raise the single young. This means adults cannot breed annually and the enormous breeding colonies – containing juveniles of different ages – maintain a permanent presence on favoured islands of the southern oceans.



SIZE 90–100 cm (35–39 in)
HABITAT Flat coastal plains and waters around sub-Antarctic islands
DISTRIBUTION Islands of S. Atlantic and S. Indian Oceans
DIET Mostly lanternfish, occasionally squid

< SPINY TONGUE
A penguin's tongue is muscular and spiny: projections on the tongue surface called papillae have evolved into backward-facing barbs that help grip fish caught in dives.

v KEEN EYE
Penguins hunt by sight and have good underwater vision. Bioluminescent lanternfish, caught on night-time dives, predominate in the diet of this species.



^ WING PROPULSION
Penguins are flightless birds, but they are propelled by feet and wings during dives. Their flipper-like wings effectively make them "fly" under water.

< DENSE FEATHERS
The feathers, arranged in an outer oily waterproof layer and inner downy insulating layers, are adapted for diving in cold water.

^ SCALY SKIN
Scales on the legs and feet are reminiscent of the reptilian roots of all birds; the dark skin may help to spread heat to eggs and young.

^ EGG PROTECTOR
The single egg is incubated above the feet and beneath a fold of warm skin called a brood pouch. Once the chick has hatched, it uses the brood pouch for shelter.

WEBBED FOOT >
The kicking action of webbed feet helps propel the bird forwards under water – and on land, when "tobogganing" over snow on its belly.

< FIRM TAIL
The short tail consists of stiffened feathers, used as a rudder under water. In smaller species, it is used as a prop on land.

COUNTERSHADED DIVER
Below its distinctive yellow markings, the king penguin has the tuxedo-style plumage pattern typical of penguins: white beneath and dark above. When diving, this pattern offers camouflage from aquatic predators. Seen from below, the pale belly is harder to see against the sunlit surface, and when seen from above, the bird's dark back blends in with the dark of the water below.

yellow markings are due to pigments called carotenoids, which are absent from some penguin species
yellow stripe on lower mandible
yellow breast

DIVERS

These web-footed, fish-eating birds of Arctic waters have rear-set legs that limit their movement on land but provide excellent thrust for swimming.

Divers are the only family in the order Gaviiformes. The alternative name for these birds – loon – may originate from their haunting "lunatic" wailing cries uttered during the breeding season, or possibly from their ungainly motion when out of water. A diver's legs are set so far back on the body that the bird can only manage an awkward shuffle on land. In water, divers swim and dive with ease. Their streamlined body and spear-like bill closely resemble those of penguins, which have similar habits – it is possible, though not certain, that these birds may share a common ancestor.

Although their pointed wings are relatively small for their body size, divers are fast fliers. To get themselves airborne, the larger species have to patter across open water; only the red-throated diver is able to take off from land. All species fly southwards to overwinter.

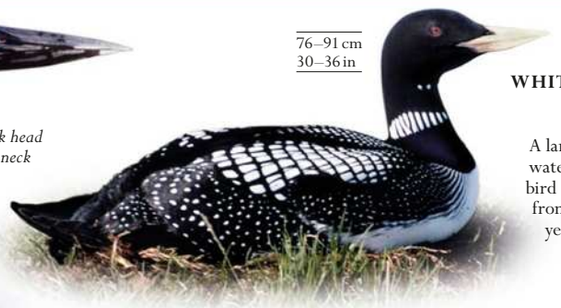
SHARED PARENTING

Territorial male divers choose nest sites in vegetation on the shores of clear Arctic lakes, where both sexes incubate and tend the young. Young diver chicks ride on the backs of their parents, but they can swim and even dive soon after hatching. After breeding, divers lose their striking head and neck patterns, and their duller body plumage makes it more difficult to distinguish the different species.

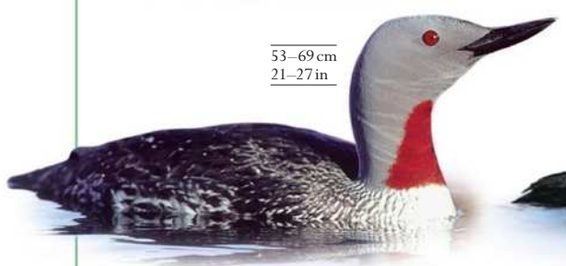
PHYLUM	CHORDATA
CLASS	AVES
ORDER	GAVIIFORMES
FAMILIES	1
SPECIES	5

Divers fly with their outstretched head held slightly lower than the body, which gives them a hunchbacked appearance.

GREAT NORTHERN DIVER
Gavia immer
F: Gaviidae
69–91 cm
27–36 in
One of the largest divers, this bird breeds on lakes in subarctic regions of N. America and Iceland. It overwinters on coasts further south, including those around Britain.



WHITE-BILLED DIVER
Gavia adamsii
F: Gaviidae
76–91 cm
30–36 in
A large species of Arctic waters, this white-billed bird can be distinguished from other divers by its yellowish white bill.



RED-THROATED DIVER
Gavia stellata
F: Gaviidae
53–69 cm
21–27 in
The smallest diver, this bird breeds on small tundra pools in circumpolar regions and migrates south to Europe, China, and the southeastern USA to overwinter.

PACIFIC DIVER
Gavia pacifica
F: Gaviidae
58–74 cm
23–29 in
This species has similar striped plumage to that of the black-throated diver. Both species have a white throat when not breeding.

BLACK-THROATED DIVER
Gavia arctica
F: Gaviidae
58–73 cm
23–29 in
Largely confined to Eurasia when breeding, this species sometimes reaches Alaska, but winters further south, including the Pacific coast of N. America.

ALBATROSSES, PETRELS, AND SHEARWATERS

Long-winged albatrosses and their relatives spend much of their lives in the air, travelling great distances as they scan the surface of the oceans for fish.

These birds, the order Procellariiformes, are master aeronauts, rarely returning to land except to breed. Albatrosses, petrels, and shearwaters – called "tubenoses" on account of the tubular nasal protuberances on their bill – are globally widespread, ocean-going birds, but show greatest diversity in the southern hemisphere.

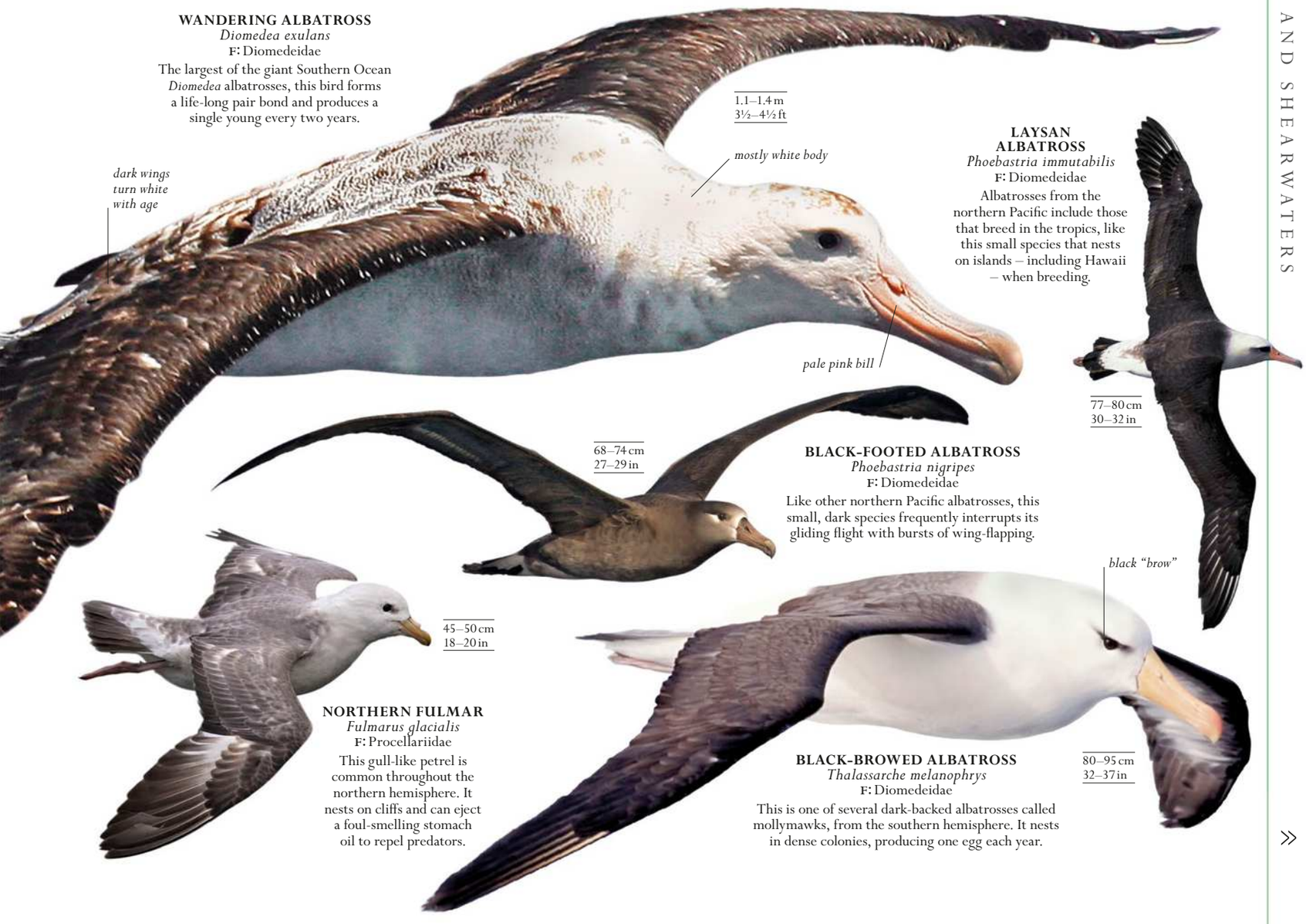
Unusually for birds, they locate their sparsely scattered sea prey by smell. All but the smallest diving species in this group have elongated wings, and almost all have their webbed feet positioned so far back that some cannot easily walk. These birds deter predators by regurgitating a noxious oil that they produce in their stomach and sometimes forcefully eject. This oil is also nutritious enough to feed their chicks.

SLOW REPRODUCTION

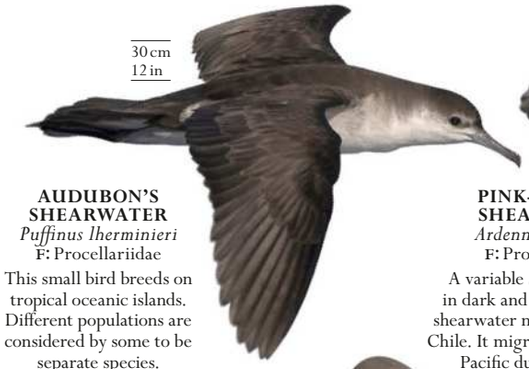
Tubenoses form pair bonds, sometimes for life, which in the larger species can be several decades. Many species breed in colonies on remote islands, often returning to the same site year after year. Smaller species nest in cavities and burrows. These birds have low breeding rates, but the parents invest heavily in rearing their young. Typically, tubenoses make only one breeding attempt per season and produce a single egg. Despite a lengthy incubation period, chicks are helpless upon hatching and mature very slowly.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PROCELLARIIFORMES
FAMILIES	4
SPECIES	147

Long-lived wandering albatrosses are monogamous. They reinforce their pair-bonding with an elaborate courtship dance.


WANDERING ALBATROSS
Diomedea exulans
F: Diomedeidae
The largest of the giant Southern Ocean Diomedea albatrosses, this bird forms a life-long pair bond and produces a single young every two years.
1.1–1.4 m
3½–4½ ft
dark wings turn white with age
mostly white body
pale pink bill
LAYSAN ALBATROSS
Phoebastria immutabilis
F: Diomedeidae
Albatrosses from the northern Pacific include those that breed in the tropics, like this small species that nests on islands – including Hawaii – when breeding.
77–80 cm
30–32 in
68–74 cm
27–29 in
BLACK-FOOTED ALBATROSS
Phoebastria nigripes
F: Diomedeidae
Like other northern Pacific albatrosses, this small, dark species frequently interrupts its gliding flight with bursts of wing-flapping.
black "brow"
45–50 cm
18–20 in
NORTHERN FULMAR
Fulmarus glacialis
F: Procellariidae
This gull-like petrel is common throughout the northern hemisphere. It nests on cliffs and can eject a foul-smelling stomach oil to repel predators.
BLACK-BROWED ALBATROSS
Thalassarche melanophrys
F: Diomedeidae
This is one of several dark-backed albatrosses called mollymawks, from the southern hemisphere. It nests in dense colonies, producing one egg each year.
80–95 cm
32–37 in

» ALBATROSSES, PETRELS, AND SHEARWATERS



AUDUBON'S SHEARWATER
Puffinus lherminieri
F: Procellariidae
This small bird breeds on tropical oceanic islands. Different populations are considered by some to be separate species.

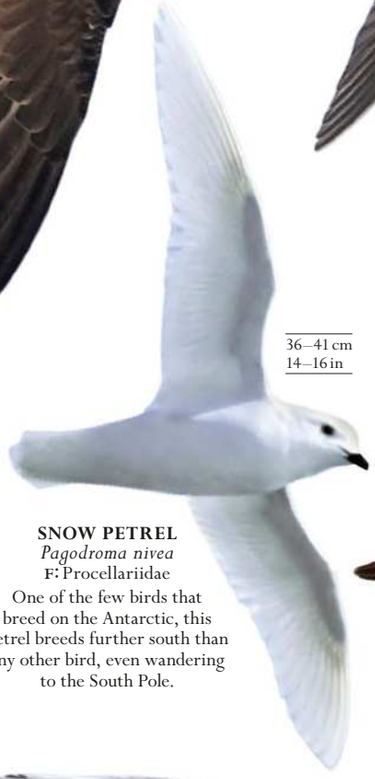
PINK-FOOTED SHEARWATER
Ardenna creatopus
F: Procellariidae
A variable species existing in dark and light forms, this shearwater nests on islands off Chile. It migrates to the eastern Pacific during summer.

BULLER'S SHEARWATER
Ardenna bulleri
F: Procellariidae
This shearwater nests on islands off N. New Zealand but roams across the Pacific outside the breeding season.

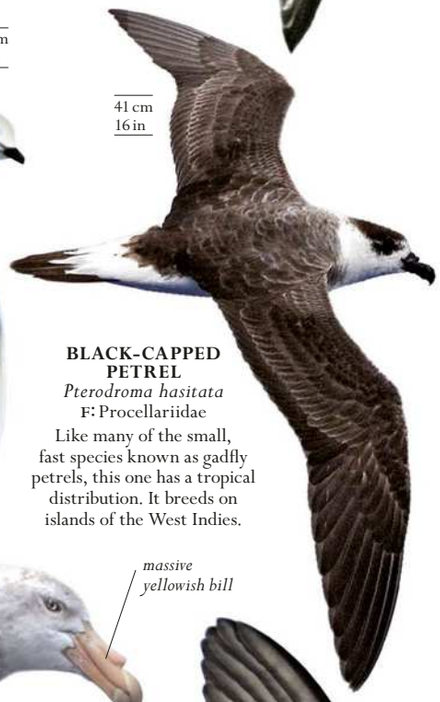
CORY'S SHEARWATER
Calonectris diomedea
F: Procellariidae
A large shearwater that glides with bowed wings, this species breeds on islands in the eastern Atlantic and disperses more widely in winter.

ANTARCTIC PRION
Pachyptila desolata
F: Procellariidae
Prions are small, grey Southern Ocean petrels that skim the sea to strain plankton with their flattened bill.

JOUANIN'S PETREL
Bulweria fallax
F: Procellariidae
A tropical petrel of the northwestern Indian Ocean, this bird has a weaving flight. It is closely related to the gliding shearwaters.

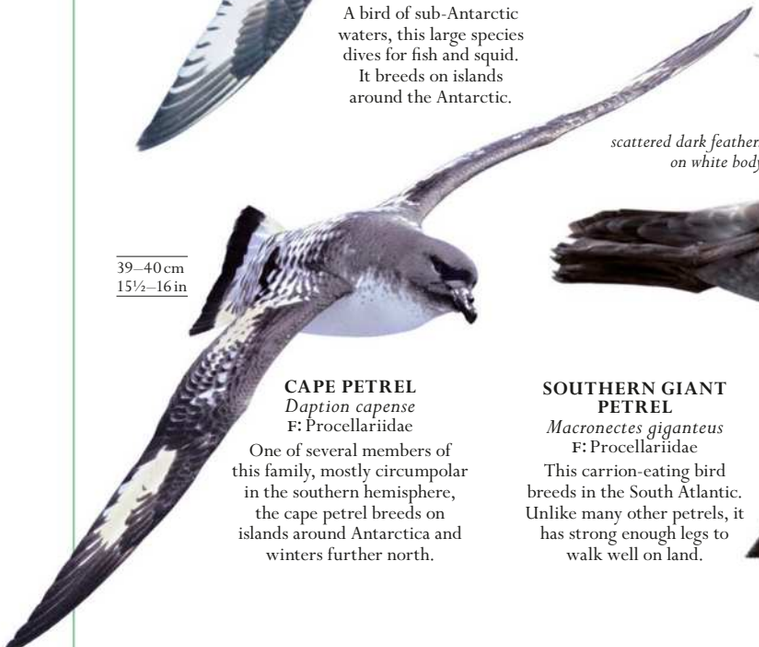


SNOW PETREL
Pagodroma nivea
F: Procellariidae
One of the few birds that breed on the Antarctic, this petrel breeds further south than any other bird, even wandering to the South Pole.

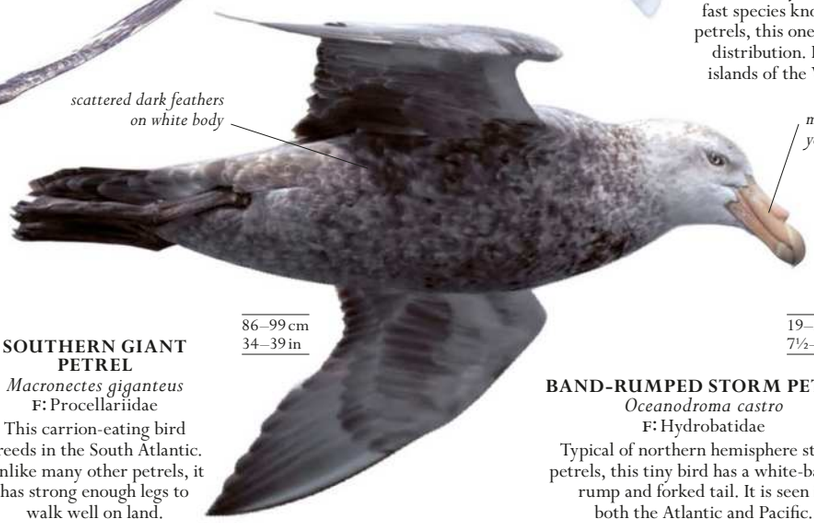


BLACK-CAPPED PETREL
Pterodroma hasitata
F: Procellariidae
Like many of the small, fast species known as gadfly petrels, this one has a tropical distribution. It breeds on islands of the West Indies.

ANTARCTIC PETREL
Thalassoica antarctica
F: Procellariidae
A bird of sub-Antarctic waters, this large species dives for fish and squid. It breeds on islands around the Antarctic.



CAPE PETREL
Daption capense
F: Procellariidae
One of several members of this family, mostly circumpolar in the southern hemisphere, the cape petrel breeds on islands around Antarctica and winters further north.



SOUTHERN GIANT PETREL
Macronectes giganteus
F: Procellariidae
This carrion-eating bird breeds in the South Atlantic. Unlike many other petrels, it has strong enough legs to walk well on land.

BAND-RUMPED STORM PETREL
Oceanodroma castro
F: Hydrobatidae
Typical of northern hemisphere storm petrels, this tiny bird has a white-banded rump and forked tail. It is seen in both the Atlantic and Pacific.

GREBES

Birds of ponds and lakes, grebes characteristically swim low in the water and dive propelled by their feet. They feed on small aquatic animals.

Like many other diving birds, grebes have legs that are set far back on the body, making them clumsy on land but agile in water. The toes of their feet are lobed, providing good power strokes during diving, but minimizing drag in the water between strokes. The feet may be used for steering, too; in other diving birds, the tail is used for steering.

A grebe's tail is nothing more than a tuft of feathers. This serves more as a social signal than as a rudder, and is often cocked to expose white feathers beneath. The plumage is dense and well waterproofed by an oil gland. Uniquely in birds, the gland produces a secretion that is 50 per cent paraffin. Grebes have small wings and many species are often reluctant to fly, although northern species are migratory, travelling from inland habitats to the coast to overwinter.

Traditionally, grebes, the order Podicipediformes, are classified as close relatives of divers, penguins, and albatrosses. However, new research suggests that they may be related to flamingos.

RITUAL AND REPRODUCTION

In the breeding season, some grebes perform elaborate courtship rituals. They nest on floating mats of vegetation in freshwater habitats. The young are fully mobile upon hatching and can swim, but seek refuge on a parent's back for the first few weeks.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PODICIPEDIFORMES
FAMILIES	1
SPECIES	23

The courtship ritual of the great crested grebe culminates with both birds rising up from the water clutching a clump of weed.

23–29 cm
9–11½ in

LITTLE GREBE
Tachybaptus ruficollis
F: Podicipedidae

Found across the Old World, this bird is the most widespread of the small, dumpy grebes known as dabchicks. It has a reddish neck when breeding.

24–36 cm
9½–14 in

WHITE-TUFTED GREBE
Rollandia rolland
F: Podicipedidae

A native of southern S. America, this is a bird of open lakes with abundant water weeds. A related short-winged Andean species is flightless.

30–38 cm
12–15 in

PIED-BILLED GREBE
Podilymbus podiceps
F: Podicipedidae

This American bird is more stocky and has a stubbier bill than other grebes. Northern birds overwinter in the Caribbean, but tropical populations are sedentary.

40–50 cm
16–20 in

grey flanks

RED-NECKED GREBE
Podiceps grisegena
F: Podicipedidae

This species breeds in Eurasia and N. America and overwinters further south in coastal waters. Like other grebes, it migrates at night.

28–34 cm
11–13½ in

BLACK-NECKED GREBE
Podiceps nigricollis
F: Podicipedidae

Like other *Podiceps* grebes, this sharp-billed diver has a colourful head plumage when breeding. It is found across the northern hemisphere.

46–51 cm
18–20 in

GREAT CRESTED GREBE
Podiceps cristatus
F: Podicipedidae

This Old World grebe is known for its courtship display. Like other grebes, both sexes are colourful.

25–29 cm
10–11½ in

SILVERY GREBE
Podiceps occipitalis
F: Podicipedidae

This S. American grebe is a colonial breeder, congregating on alkaline or salty lakes. It is found from the Andes to the Falkland Islands.

black head

55–75 cm
22–30 in

WESTERN GREBE
Aechmophorus occidentalis
F: Podicipedidae

One of two similar western N. American grebes, this species has a range from Canada to Mexico; northern populations winter off the Pacific coast.

dark grey back

white throat, breast, and belly

FLAMINGOS

These remarkable birds live on salty lagoons and alkaline lakes. Once classified with storks, flamingos are now thought to be related to grebes.

Extreme gregariousness defines flamingo life. These birds of the order Phoenicopteriformes congregate in huge flocks, sometimes numbering hundreds of thousands. These vast groups are so tightly packed that individual birds cannot easily take flight and must initially walk or run if disturbed. But the open habitat that flamingos favour, coupled with the vigilance of many birds, ensures that predators are easily spotted.

The large flocks are necessary to stimulate breeding, and flamingo courtship involves group displays. Pairs build mud nests and territory is simply determined by how far a bird's neck will stretch from the nest. A few days after hatching, flamingo chicks gather together in large crèches. The parent birds feed their young with a liquid food called crop milk.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PHOENICOPTERIFORMES
FAMILIES	1
SPECIES	6

FILTER FEEDERS

Flamingos have a unique style of filter-feeding using a specially adapted bill. Holding its head upside-down, a flamingo strains planktonic algae and shrimps from the water through hair-like structures lining the bill. Pigments absorbed from the food give flamingos their characteristic pink colour. There are few competitors for food, as the organisms are taken from otherwise barren inland waters that are either very salty or caustic.

Some of the biggest flocks of flamingos are seen in the African Rift Valley, where lesser flamingos gather to feed.

CHILEAN FLAMINGO
Phoenicopterus chilensis
F: Phoenicopteridae
The most widespread flamingo in S. America, the Chilean flamingo has a range from Peru to Tierra del Fuego, and is distinguished by grey legs with pink "knees".
1–1.3 m
3¼–4¼ ft
pinkish white plumage
pink "knee" is the ankle
slender grey leg
black-tipped bill
1.2–1.4 m
4–4½ ft
CARIBBEAN FLAMINGO
Phoenicopterus ruber
F: Phoenicopteridae
This Caribbean species differs from the greater flamingo in being somewhat smaller and having a pinker plumage.
extremely long neck
pale pink bill
bright red wing feathers
1.1–1.5 m
3½–5 ft
GREATER FLAMINGO
Phoenicopterus roseus
F: Phoenicopteridae
With a range spanning Africa, S. Europe, and C. Asia, this is the largest and most widespread of the flamingos.
1–1.1 m
3¼–3½ ft
ANDEAN FLAMINGO
Phoenicoparrus andinus
F: Phoenicopteridae
One of two flamingo species restricted to the higher altitudes of the Andes, this distinctively yellow-legged flamingo may wander nomadically between lakes for food.
LESSER FLAMINGO
Phoeniconaias minor
F: Phoenicopteridae
The smallest flamingo, this species from Africa and southern Asia occurs in huge numbers on highly alkaline lakes.
80–100 cm
32–39 in

STORKS

Most species in this group are wetland birds with long legs for walking through marshy or grassy habitats. They snatch prey with their long bill.

Storks, order Ciconiformes, are tall, upright birds, most often found in open spaces. While some are heron-like waterside species, others forage on dry ground. They have a long-striding walk but can perch on open branches and many nest in trees. Their varied diet includes fish, amphibians, small reptiles and mammals, and large insects. In Africa, storks feed on small animals fleeing grassland fires, and exploit swarms of locusts and grasshoppers.

Storks have a strong and more or less pointed bill. The marabou uses its heavy, powerful bill for everything from displacing vultures at carcasses of dead mammals to scavenging at refuse tips. Other storks have slimmer bills, some more or less tapered to an upswept or downcurved tip.

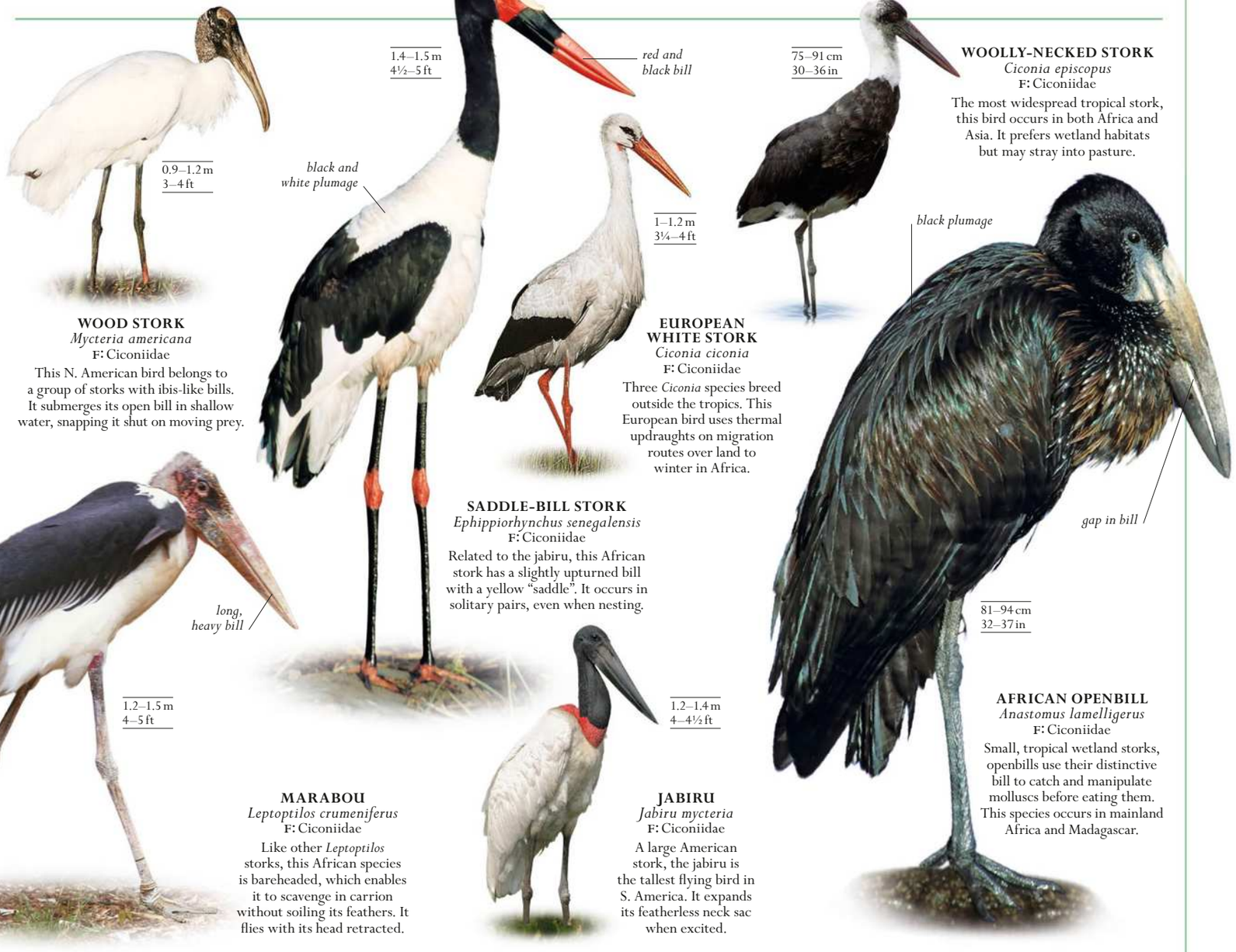
All storks have broad wings with "fingered" tips. They soar on rising thermals of warm air to gain height before gliding off over great distances to a new feeding area or on long migratory journeys. Large flocks of white storks cross the Mediterranean Sea at its narrower points, in the same way as migratory birds of prey.

COLONIAL NESTING

Many birds of this group are gregarious when breeding, and their nesting colonies may include several species. All species produce helpless young that must be reared in the nest for some weeks.

CLASS	CHORDATA
AVES	AVES
ORDER	CICONIIFORMES
FAMILIES	1
SPECIES	19

Storks typically nest in trees, but in western Europe white storks make good use of level platforms high on buildings.



WOOD STORK
Mycteria americana
F: Ciconiidae
This N. American bird belongs to a group of storks with ibis-like bills. It submerges its open bill in shallow water, snapping it shut on moving prey.

SADDLE-BILL STORK
Ephippiorhynchus senegalensis
F: Ciconiidae
Related to the jabiru, this African stork has a slightly upturned bill with a yellow "saddle". It occurs in solitary pairs, even when nesting.

EUROPEAN WHITE STORK
Ciconia ciconia
F: Ciconiidae
Three *Ciconia* species breed outside the tropics. This European bird uses thermal updraughts on migration routes over land to winter in Africa.

WOOLLY-NECKED STORK
Ciconia episcopus
F: Ciconiidae
The most widespread tropical stork, this bird occurs in both Africa and Asia. It prefers wetland habitats but may stray into pasture.

MARABOU
Leptoptilos crumeniferus
F: Ciconiidae
Like other *Leptoptilos* storks, this African species is bareheaded, which enables it to scavenge in carrion without soiling its feathers. It flies with its head retracted.

JABIRU
Jabiru mycteria
F: Ciconiidae
A large American stork, the jabiru is the tallest flying bird in S. America. It expands its featherless neck sac when excited.

AFRICAN OPENBILL
Anastomus lamelligerus
F: Ciconiidae
Small, tropical wetland storks, openbills use their distinctive bill to catch and manipulate molluscs before eating them. This species occurs in mainland Africa and Madagascar.

IBISES, BITTERNS, HERONS, AND PELICANS

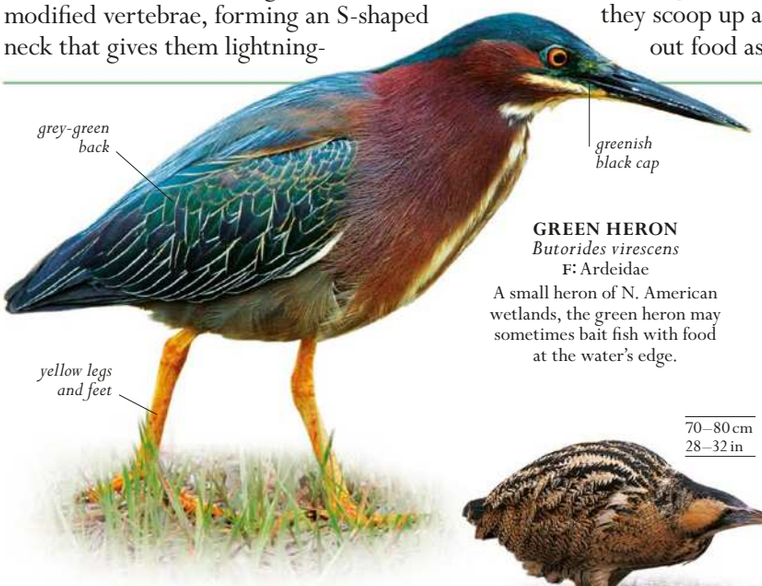
Most species in the order Pelicaniformes are wetland birds with long legs for walking through marshy or grassy habitats. Their long toes help them to stretch forward when hunting or grasp perches in mangrove swamps or wet thickets. These birds have a long bill for snatching prey.

While most birds in this group eat amphibians and fish, they sometimes eat small mammals and insects as well. Herons, egrets, and bitterns have modified vertebrae, forming an S-shaped neck that gives them lightning-fast thrust to snatch, but not spear, prey. Ibises probe for prey with their thin, curved bill, whereas spoonbills sweep their partly opened bill – with a flat, rounded tip – sideways through shallow water in search of food. The bill snaps shut when prey is detected by touch. Herons and egrets retract their necks in flight, unlike spoonbills and ibises.

Pelicans are massively built, but broad-winged and expert fliers. They have a long bill with a deep, flexible pouch. When feeding (mostly when swimming, but brown pelicans also plunge-dive) they scoop up a large volume of water, filtering out food as the pouch empties.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PELICANIFORMES
FAMILIES	5
SPECIES	118

This pelican chick reaches deep into its parent's throat to feed on regurgitated, partly digested fish.



GREEN HERON
Butorides virescens
F: Ardeidae

A small heron of N. American wetlands, the green heron may sometimes bait fish with food at the water's edge.

40–55 cm
16–22 in

80–100 cm
32–39 in

GREAT EGRET
Ardea alba
F: Ardeidae

Not a true egret but a large white heron, this marsh bird is widespread throughout much of the world.

90–98 cm
35–39 in

GREY HERON
Ardea cinerea
F: Ardeidae

Familiar across Eurasia and Africa, the grey heron, like other larger herons, breeds in colonies. It builds stick nests in trees.

70–80 cm
28–32 in

EURASIAN BITTERN
Botaurus stellaris
F: Ardeidae

Like its relatives, this bittern is more frequently heard than seen. It has a loud booming call.

27–38 cm
10½–15 in

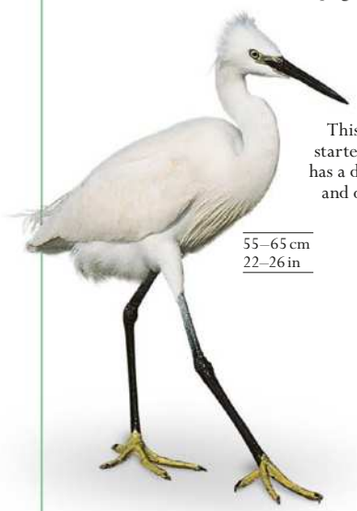
LITTLE BITTERN
Ixobrychus minutus
F: Ardeidae

Among the smallest of the heron-bittern family, this skulking Old World species clambers around reeds – sometimes freezing upright in typical bittern manner.

80–100 cm
32–39 in

WHITE-NECKED HERON
Ardea pacifica
F: Ardeidae

This large heron of wet regions in Australia and New Guinea hunts for insects and small vertebrates in marshes and grassland.



55–65 cm
22–26 in

LITTLE EGRET
Egretta garzetta
F: Ardeidae

This Old World species has started to colonize America. It has a distinct black bill and legs, and one race has yellow feet.

60–70 cm
23½–28 in

WHITE-FACED HERON
Egretta novaehollandiae
F: Ardeidae

A member of the egret group from Indonesia, Australia, and New Zealand, this species has a varied diet that includes insects and frogs.

55–57 cm
22–22½ in

TRICOLOURED HERON
Egretta tricolor
F: Ardeidae

This is an inhabitant of American swamps, where, like related species, it uses its dagger-like bill to snatch small animals.

58–63 cm
23–25 in

LITTLE BLUE HERON
Egretta caerulea
F: Ardeidae

This American species belongs to the egret group. The purplish head and neck turn grey-blue outside the breeding season.

CATTLE EGRET
Bubulcus ibis
F: Ardeidae

Actually a small white heron, this globally widespread species forages on grassland and often follows livestock to catch disturbed prey.

INDIAN POND HERON
Ardeola grayii
F: Ardeidae

Common in S. Asia, this heron stalks aquatic prey, but it may also flush fish by flying low over water.

BOAT-BILLED HERON
Cochlearius cochlearius
F: Ardeidae

This heron has a broad bill, adapted for scooping animal prey. It inhabits C. and S. American mangrove swamps.

BLACK-CROWNED NIGHT HERON
Nycticorax nycticorax
F: Ardeidae

Night herons have good night vision. Found in most warm regions except Australia, this is the most widespread species.

STRAW-NECKED IBIS
Threskiornis spinicollis
F: Threskiornithidae

So called because of the straw-like feathers at the base of its neck, this nomadic ibis occurs in New Guinea and Australia.

SACRED IBIS
Threskiornis aethiopicus
F: Threskiornithidae

This is a common bird of the wetlands and grasslands of Africa and Madagascar. It has been introduced into America and Europe.

SCARLET IBIS
Eudocimus ruber
F: Threskiornithidae

The national bird of Trinidad, the scarlet ibis occurs in tropical America and acquires its scarlet pigment from eating crustaceans.

REDDISH EGRET
Egretta rufescens
F: Ardeidae

This American species has white and reddish grey colour forms. When fishing, it sometimes holds out its wings to reduce sun glare.

AUSTRALIAN IBIS
Threskiornis molucca
F: Threskiornithidae

This is a common species throughout Australia. It often invades urban areas, where it is sometimes considered a pest.

HADADA IBIS
Bostrychia hagedash
F: Threskiornithidae

A common African species found in grasslands, forests, parks, and gardens, the hadada ibis is named after its distinctive flight call.

BLACK-FACED IBIS
Theristicus melanopis
F: Threskiornithidae

Found in S. America, this species occurs in temperate grassland habitat from the Andes to Patagonia.

GLOSSY IBIS
Plegadis falcinellus
F: Threskiornithidae

Found throughout warm parts of the world, this is the most widespread ibis species. Its tree-nesting colonies may be accompanied by herons.

»

AFRICAN SPOONBILL
Platalea alba
F: Threskiornithidae

The only spoonbill confined to wetlands of Africa, this species is characterized by its red face and legs.

90–92 cm
35–36 in

80–90 cm
32–35 in

EURASIAN SPOONBILL
Platalea leucorodia
F: Threskiornithidae

This species breeds in Eurasia and overwinters in Africa. Mature birds have a broad yellow tip to the black bill.

grey plumage

large bill

1.2–1.5 m
4–5 ft

pinkish red patch on wing

pink breast tuft when breeding

ROSEATE SPOONBILL
Platalea ajaja
F: Threskiornithidae

Like other spoonbills, this distinctive American species feeds on small aquatic animals by swinging its bill from side to side in water.

71–86 cm
28–34 in

SHOEBILL
Balaeniceps rex
F: Balaenicipitidae

Restricted to swamps from Sudan to Zambia, this wading bird uses its huge bill to scoop vertebrate prey from muddy waters.

56 cm
22 in

HAMMERKOP
Scopus umbretta
F: Scopidae

This African wetland bird builds huge, heavy-walled nests using sticks and mud to protect its young, who are often left for long periods.

bold head and neck pattern

orange throat pouch

all-white plumage

1.3–1.6 m
4¼–5¼ ft

1–1.4 m
3¼–4½ ft

1.3–1.5 m
4¼–5 ft

AMERICAN WHITE PELICAN
Pelecanus erythrorhynchos
F: Pelecanidae

This pelican breeds on inland lakes of N. America and overwinters on the coasts. In the breeding season, it develops a flat "horn" on its bill.

SPOT-BILLED PELICAN
Pelecanus philippensis
F: Pelecanidae

A species from S. Asia, the spot-billed pelican, like most other pelicans, fishes by scooping prey while swimming on the water surface.

BROWN PELICAN
Pelecanus occidentalis
F: Pelecanidae

This grey and brown pelican from the S. USA to S. America is a coastal-breeding species and, unlike other pelicans, plunge-dives for fish.

CORMORANTS, GANNETS, AND RELATIVES

The order Suliformes includes marine species, though some cormorants and anhingas also visit freshwater habitats. The birds in this group have webbing between all four toes.

Frigatebirds cross vast areas of sea but rarely settle on water, taking flying fish or stealing food from other seabirds in the air. Cormorants and anhingas feed on a variety of aquatic species by diving from the surface, while gannets and boobies plunge from a height and are more exclusively fish-eaters.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	SULIFORMES
FAMILIES	4
SPECIES	61

81 cm
32 in

BLUE-FOOTED BOOBY
Sula nebouxii
F: Sulidae

Found on rocky coasts from California to Peru and the Galapagos Islands, this booby flaunts its blue feet as part of its courtship display.

MASKED BOOBY
Sula dactylatra
F: Sulidae

This is the largest of the tropical boobies, with a black and white plumage and long, yellow bill. It most closely resembles the related cold-water gannets.

80–92 cm
31–36 in

75–95 cm
30–37 in

ANHINGA
Anhinga anhinga
F: Anhingidae

This American species has a long, cormorant-like neck and a straight bill for spearing fish. Anhingas are also called snake birds or darters.

71 cm
28 in

RED-FACED SHAG
Phalacrocorax urile
F: Phalacrocoracidae

A deep-diving seabird found from Japan to the Bering Sea, this species belongs to a group of North Pacific cormorants that are highly adapted to the marine environment.

90–100 cm
3–3¼ ft

NORTHERN GANNET
Morus bassanus
F: Sulidae

The three similar species of cold-water gannets breed in large colonies on rocky coasts. This one is a native of the North Atlantic.

50–55 cm
20–22 in

LITTLE PIED CORMORANT
Microcarbo melanoleucos
F: Phalacrocoracidae

This is an Australasian member of a group of primitive, short-billed "micro-cormorants" that are largely associated with freshwater or estuarine habitats.

1–1.1 m
3¼–3½ ft

MAGNIFICENT FRIGATEBIRD
Fregata magnificens
F: Fregatidae

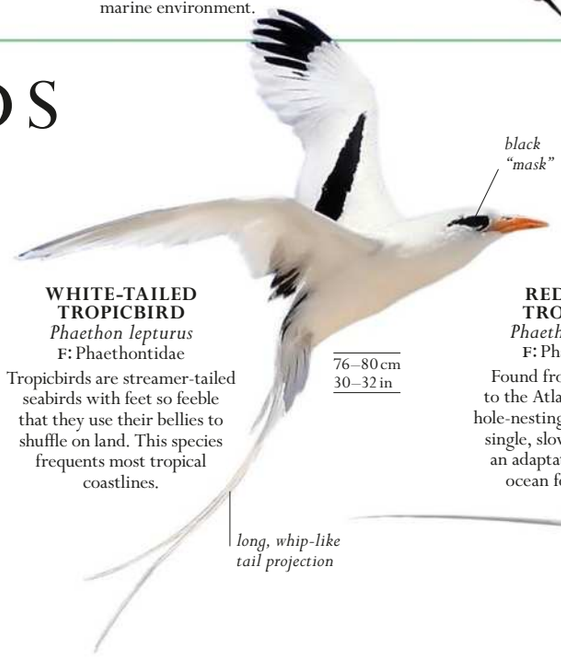
Infrequent feeding opportunities and long hours in flight cause frigatebirds, such as this American species, to have a low breeding rate and the longest period of parental care of any bird.

TROPICBIRDS

Large, tern-like seabirds with a long, spike-like tail projection, tropicbirds nest on tropical islands and forage widely at sea.

The three species in this order, the Phaethontiformes, have all four toes joined by webs, like gannets and boobies, but are unable to stand. They locate fish by sight while hovering before plunging from the air. At their breeding colonies, groups of males display in swirling, circular flights, swaying their tail spike to impress watching females.

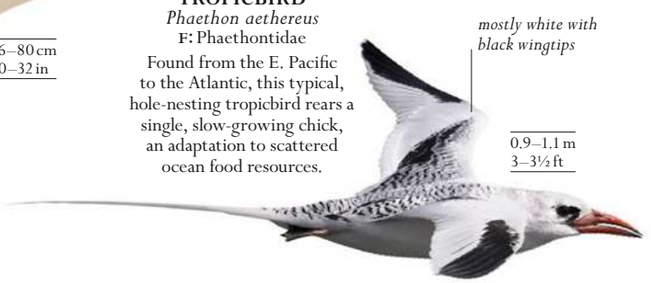
PHYLUM	CHORDATA
CLASS	AVES
ORDER	PHAETHONTIFORMES
FAMILIES	1
SPECIES	3



76–80 cm
30–32 in

WHITE-TAILED TROPICBIRD
Phaethon lepturus
F: Phaethontidae

Tropicbirds are streamer-tailed seabirds with feet so feeble that they use their bellies to shuffle on land. This species frequents most tropical coastlines.



0.9–1.1 m
3–3½ ft

RED-BILLED TROPICBIRD
Phaethon aethereus
F: Phaethontidae

Found from the E. Pacific to the Atlantic, this typical, hole-nesting tropicbird rears a single, slow-growing chick, an adaptation to scattered ocean food resources.

BIRDS OF PREY

The largest and most important group of day-flying hunters, almost all the birds in the order Accipitriformes are exclusively meat-eaters. In some habitats they are the top predators.

Large birds of prey, such as the harpy eagle and Philippine eagle of tropical rainforests, are so powerful they can kill large monkeys and small deer. The largest species, which include Old World vultures and American condors, feed on dead animals, and many, such as kites and buzzards, eat carrion as well as catch live prey. Exceptions include the largely vegetarian palm-nut vulture of Africa.

Birds of prey typically have keen vision and hunt by sight. The turkey vulture detects prey by smell, and other species watch and follow it down to hidden carcasses. Birds in this group have a strong, hooked bill for dismembering prey. Larger vultures are well-equipped to rip hide and flesh but have relatively weak feet. Most have a bare head, which prevents an unhygienic, sticky mess when probing inside animal carcasses. New World vultures may be more closely related to storks than to the similar-looking Old World vultures. Eagles, hawks, buzzards, and kites have stronger feet with long, curved, sharp claws, used for catching and killing prey. The unique secretary bird of African plains hunts on foot.

Some kites have a forked tail for greater control in flight. Bird-eating hawks have rather short wings and a long tail, for extra manoeuvrability through woodland, while other species have longer, broader wings that allow them to soar on rising air currents and glide long distances with little effort. In this way, heavy vultures can move very long distances to find food each day, and some species perform very long annual migrations. Their "fingered" wingtips reduce turbulence at the wingtip, giving greater efficiency.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	ACCIPITRIFORMES
FAMILIES	4
SPECIES	266

The pale underwings of a turkey vulture catch the sunlight as it tilts, twists, and turns, searching for food below.

64–81 cm
25–32 in

TURKEY VULTURE
Cathartes aura
F: Cathartidae
Unusually for birds, this widespread American vulture locates rotting carcasses by smell. It often nests in dark recesses, such as under large rocks or stumps.

67–81 cm
26–32 in

contrasting black and white wings

56–66 cm
22–26 in

white streaks on massive wings

KING VULTURE
Sarcoramphus papa
F: Cathartidae
This large bird soars high above forests of tropical America looking for carrion. It is distinguished by its colourful head and fleshy bill wattle.

BLACK VULTURE
Coragyps atratus
F: Cathartidae
More gregarious than the related turkey vulture, the black vulture is an opportunistic scavenger found from the C. USA to Chile.

ANDEAN CONDOR
Vultur gryphus
F: Cathartidae
S. America's largest flying land bird, this species soars on updraughts in the Andes, locating carrion by sight or by following other scavengers, such as turkey vultures.

52–60 cm
20½–23½ in

EUROPEAN HONEY-BUZZARD
Pernis apivorus
F: Accipitridae

Belonging to a group of tropical raptors that eat bee and wasp larvae, this species breeds in Eurasia and overwinters in Africa.

51–57 cm
20–22½ in

EURASIAN BUZZARD
Buteo buteo
F: Accipitridae

A common raptor, this species has light and dark colour forms. Its northern populations overwinter in tropical Africa and Asia.

50–65 cm
20–26 in

LONG-LEGGED BUZZARD
Buteo rufinus
F: Accipitridae

This buzzard of semi-deserts and mountains breeds in C. Europe and C. Asia, with some populations migrating to N. Africa in winter.

32–38 cm
12½–15 in

WHITE-TAILED KITE
Elanus leucurus
F: Accipitridae

Typical of its genus, this sharp-browed kite habitually hovers when hunting. It occurs from the USA to S. America, outside the Amazon basin.

WHITE-EYED BUZZARD
Butastur teesa
F: Accipitridae

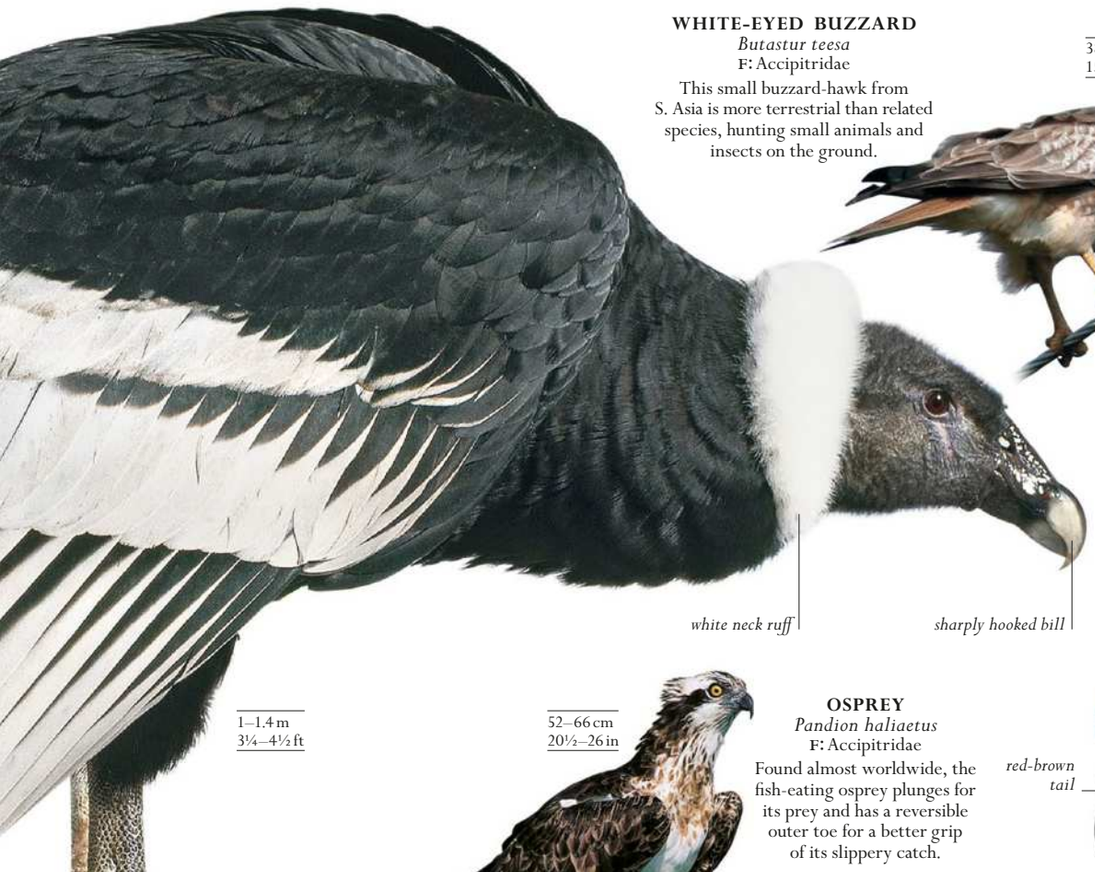
This small buzzard-hawk from S. Asia is more terrestrial than related species, hunting small animals and insects on the ground.

38–43 cm
15–17 in

50–64 cm
20–25 in

SWALLOW-TAILED KITE
Elanoides forficatus
F: Accipitridae

This insect-eating bird of prey is a graceful and agile flier. It breeds in the S.E. USA and C. America, and overwinters in S. America.



1–1.4 m
3¼–4½ ft

BRAHMINY KITE
Haliastur indus
F: Accipitridae

With a range from India to Australasia, this riverside and coastal scavenger also hunts for live prey such as fish and small mammals.

43–51 cm
17–20 in

52–66 cm
20½–26 in

OSPREY
Pandion haliaetus
F: Accipitridae

Found almost worldwide, the fish-eating osprey plunges for its prey and has a reversible outer toe for a better grip of its slippery catch.

60 cm
23½ in

PALM-NUT VULTURE
Gypohierax angolensis
F: Accipitridae

Unusually for a vulture, this African species has a largely vegetarian diet, consisting of oil palm fruit. However, it also feeds on fish and carrion.

1.3–1.5 m
4¼–5 ft

SECRETARY BIRD
Sagittarius serpentarius
F: Accipitridae

One of the few raptors to hunt on the ground, this long-legged bird of African savanna chases small animals, often stamping to disable them.

»

71–96 cm
28–38 in

BALD EAGLE
Haliaeetus leucocephalus
F: Accipitridae

This N. American sea eagle, the USA's national emblem, captures or scavenges fish, sometimes hunting co-operatively. It breeds in woodland near water.

WHITE-BELLIED SEA EAGLE
Haliaeetus leucogaster
F: Accipitridae

With a distribution from India to Australasia along lakes and rivers, like other large eagles, this fishing raptor builds huge stick nests.

70–90 cm
28–35 in

55–72 cm
22–28 in

BONELLI'S EAGLE
Aquila fasciatus
F: Accipitridae

A woodland- and mountain-dwelling species, this long-winged buzzard-like eagle has a range that extends from S. Eurasia to N. Africa.

72–85 cm
28–34 in

WHITE-HEADED VULTURE
Trigonoceps occipitalis
F: Accipitridae

Found in N., E., and S. Africa, this vulture is often seen in pairs, and is usually outnumbered by other vulture species when feeding on carcasses.

70–83 cm
28–33 in

EGYPTIAN VULTURE
Neophron percnopterus
F: Accipitridae

A relative of the palm-nut vulture, this bird of S. Eurasia and Africa routinely uses rocks to crack open ostrich eggs.

60–70 cm
23½–28 in

55–65 cm
22–26 in

AFRICAN HAWK-EAGLE
Aquila spilogaster
F: Accipitridae

A small raptor from sub-Saharan Africa, this hawk eagle hunts in wooded savanna and hilly country.

EASTERN IMPERIAL EAGLE
Aquila heliaca
F: Accipitridae

True eagles, including those of the *Aquila* genus, such as this Eurasian species, are described as "booted" because of their fully feathered legs.

GOLDEN EAGLE
Aquila chrysaetos
F: Accipitridae

A graceful soaring bird, this large, long-tailed eagle occurs in open country across the northern hemisphere. It frequents forests in some regions.

61–75 cm
24–30 in

CHANGEABLE HAWK-EAGLE
Spizaetus cirrhatus
F: Accipitridae

Often crested, Asian hawk-eagles are forest raptors. This variable species has dark and pale forms and is found from the Himalayas to Indonesia.

AFRICAN WHITE-BACKED VULTURE
Gyps africanus
F: Accipitridae

One of the commonest vultures of the sub-Saharan savanna, this species gathers in large numbers near carcasses. These birds are seen in towns and villages.

90–98 cm
35–39 in

85–97 cm
34–38 in

RÜPPELL'S VULTURE
Gyps rueppelli
F: Accipitridae

An African relative of the Eurasian griffon, this darker species inhabits arid areas. It has been recorded as flying at higher altitudes than any other bird.

EURASIAN GRIFFON
Gyps fulvus
F: Accipitridae

This vulture occurs in mountainous regions of S.W. Eurasia and N.E. Africa. It breeds and roosts among rocks and on ledges.

neck ruff turns white with age

bulbous bill

0.9–1.1 m
3–3½ ft

1–1.2 m
3¼–4 ft

LAPPET-FACED VULTURE
Torgos tracheliotus
F: Accipitridae

Like the related *Gyps* vultures, this carrion-eater of arid Africa has a long neck and a bare head to prevent carcasses from soiling its plumage.

1–1.3 m
3¼–4¼ ft

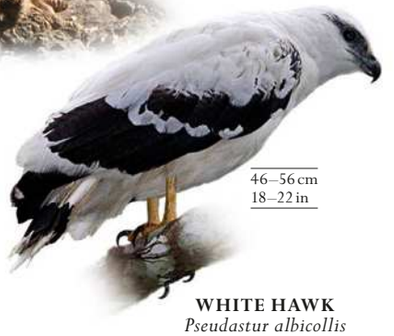
BEARDED VULTURE
Gypaetus barbatus
F: Accipitridae

Native to the mountains of Africa and Eurasia, this diamond-tailed, solitary vulture subsists largely on marrow obtained by dropping bones on rocks to split them open.

46–51 cm
18–20 in

BLACK-COLLARED HAWK
Busarellus nigricollis
F: Accipitridae

A relative of the snail kite, this species occurs in C. and S. American wetlands, where it fishes by dropping feet first into floating vegetation.



46–56 cm
18–22 in

WHITE HAWK
Pseudastur albicollis
F: Accipitridae

This forest hawk of C. and S. America hunts for reptiles, especially snakes. It has been described as lethargic and easily approached.

36–40 cm
14–16 in

60–66 cm
23½–26 in

43–56 cm
17–22 in

DARK CHANTING GOSHAWK
Melierax metabates
F: Accipitridae

An African hawk of dry, open country, this bird resembles a harrier when in flight. It has a musical piping call.

SNAIL KITE
Rostrhamus sociabilis
F: Accipitridae

This bird from Florida and C. and S. American marshes has a strongly curved bill, adapted for feeding on aquatic snails.

AFRICAN HARRIER-HAWK
Polyboroides typus
F: Accipitridae

This raptor from sub-Saharan Africa eats oil-palm fruit and hunts small vertebrates. Its flexible "double-jointed" legs help it take prey from tree-holes.

»

RÜPPELL'S VULTURE
Gyps rueppelli

One of the iconic scavengers of the African plains, from Senegal east to Sudan and Tanzania, Rüppell's vulture flies so high in roaming for food that its blood is specially adapted to capture oxygen in the thin air. This vulture patrols dry mountainous terrain, leaving its cliff-top roost sites in early morning to rise on updraughts instead of thermals. It uses acute vision to find carcasses and will wait patiently – days, if necessary – for predators to leave a kill. Like most vultures, it eats soft, rotting flesh and offal. However, its longer neck means it can reach deeper into corpses than many of its competitors – gorging its fill until, with some difficulty, it returns to the skies.

SIZE 85–97 cm (34–38 in)
HABITAT Gorges in dry, open country
DISTRIBUTION North and East Africa
DIET Carrion

> THIRD EYELID
A typical feature of birds, this membrane cleans the surface of the eye, and may help protect against flying debris during frenzied feeding.

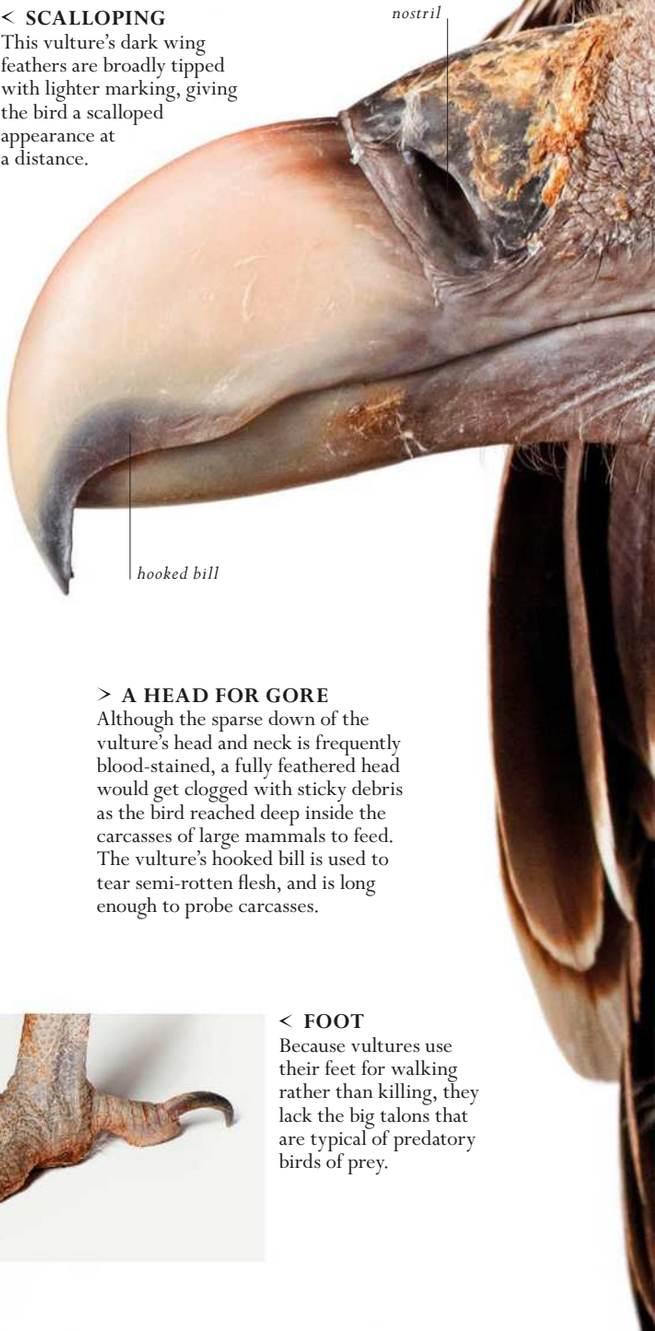
v WHITE COLLAR
White fluffy feathers encircling the base of the neck form a ruff. This may be discoloured with dust and blood from carcasses.

< SCALLOPING
This vulture's dark wing feathers are broadly tipped with lighter marking, giving the bird a scalloped appearance at a distance.

< PLUMAGE
Beneath the patterned feathers that mark out the contours of the body are fluffy down feathers that trap body heat – vital at high altitude.

^ WING
Long, broad wings help the vulture soar or glide, saving energy. Takeoff can be a struggle after a heavy meal.

< LEG
Although the bird's upper legs are feathered, its lower legs are bare and so remain relatively clean when the bird is feeding on carcasses.



> A HEAD FOR GORE
Although the sparse down of the vulture's head and neck is frequently blood-stained, a fully feathered head would get clogged with sticky debris as the bird reached deep inside the carcasses of large mammals to feed. The vulture's hooked bill is used to tear semi-rotten flesh, and is long enough to probe carcasses.

< FOOT
Because vultures use their feet for walking rather than killing, they lack the big talons that are typical of predatory birds of prey.

pinkish grey skin
of head and neck
has a light coating
of down

43–47 cm
17–18½ in

MONTAGU'S HARRIER
Circus pygargus
F: Accipitridae

Eurasian harriers, such as the Montagu's harrier, migrate to Africa and S. Asia. This species inhabits grassland and reed beds.

♀
48–56 cm
19–22 in

WESTERN MARSH HARRIER
Circus aeruginosus
F: Accipitridae

The males of this species are brown, like the females, with grey on their wings and tail. Males of other harrier species are all grey.

44–52 cm
17½–20½ in

NORTHERN HARRIER
Circus hudsonius
F: Accipitridae

Harriers are characterized by a narrow tail; narrow, pointed wings; and long legs. This species is widespread in North America.

30–37 cm
12–14½ in

LIZARD BUZZARD
Kaupifalco monogrammicus
F: Accipitridae

A native of the African savanna, this bird mostly preys on large insects, such as grasshoppers, but also eats small vertebrates.

63–68 cm
25–27 in

BLACK-BREASTED SNAKE EAGLE
Circaetus pectoralis
F: Accipitridae

A bird of African grasslands, this eagle feeds on lizards and small mammals as well as snakes.

48–62 cm
19–24 in

NORTHERN GOSHAWK
Accipiter gentilis
F: Accipitridae

This large hawk from N. America and Eurasia is capable of manoeuvring through tall trees to catch squirrels and grouse.

28–40 cm
11–16 in

EURASIAN SPARROWHAWK
Accipiter nisus
F: Accipitridae

One of nearly 50 species of *Accipiter* hawks, this hunter of small birds is found in woodland habitats from Europe to Japan.

25–35 cm
10–14 in

SHIKRA
Accipiter badius
F: Accipitridae

A typical *Accipiter* hawk with a long tail and short wings, the Old World shikra has a dashing flight for catching small animals, including birds.

60–66 cm
23½–26 in

RED KITE
Milvus milvus
F: Accipitridae

Like other *Milvus* kites, this species from Europe and the Middle East is slightly weak footed, but accomplished at soaring. It frequently feeds on carrion.

55–60 cm
22–23½ in

BLACK KITE
Milvus migrans
F: Accipitridae

Found in open country across Eurasia, Africa, and Australasia, the black kite has a varied diet that includes live fish and small mammals, carrion, and sometimes human refuse.

55–75 cm
22–30 in

CRESTED SERPENT EAGLE
Spilornis cheela
F: Accipitridae

Belonging to a group of Asian snake eagles, this species inhabits a range from India to the Philippines, and is often found near fresh water.

red facial skin
long, broad wings
red feet

55–70 cm
22–28 in

BATELEUR
Terathopius ecaudatus
F: Accipitridae

This African savanna bird is the only snake eagle that regularly eats carrion. *Bateleur* means "acrobat" in French, a reference to this bird's acrobatic flight.

FALCONS AND CARACARAS

Falcons are no longer considered to be closely related to the main order of birds of prey, the Accipitriformes, but instead have their own order, the Falconiformes.

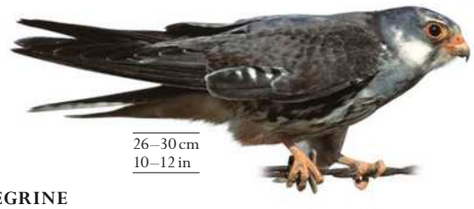
Falcons have a hooked bill, similar to that of the Accipitriformes, but with an added "notch" used to kill prey that is caught and held in the feet. They also have strong feet with sharp, curved claws. Most have long wings and are marvellous fliers. Some falcons hunt by catching large insects and birds in the air, while others dive onto prey on the ground. Some even take on larger birds in dramatic dives, stooping to strike at speed. Several "hover" at a fixed point above the ground, to search for prey below, often detecting them by the ultraviolet light emitted by their urine. Caracaras also hunt and scavenge on the ground. Unlike most true birds of prey, falcons make no nest but lay eggs on a ledge or in an old nest of some other species.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	FALCONIFORMES
FAMILIES	1
SPECIES	67

34–58 cm
13½–23 in

PEREGRINE FALCON
Falco peregrinus
F: Falconidae

As the fastest bird of prey, this falcon dives steeply on prey in mid-air. It is found throughout the world in open country, including tundra and semi-desert.



26–30 cm
10–12 in

AMUR FALCON
Falco amurensis
F: Falconidae

Unusually for falcons, this raptor habitually gathers in flocks; it breeds in marshy woodland across Siberia and China and migrates to southern Africa to overwinter.

20–31 cm
8–12 in

AMERICAN KESTREL
Falco sparverius
F: Falconidae

Kestrels are small falcons that habitually hover when hunting. This species is distributed throughout the Americas, including the Caribbean islands.

24–33 cm
9½–13 in

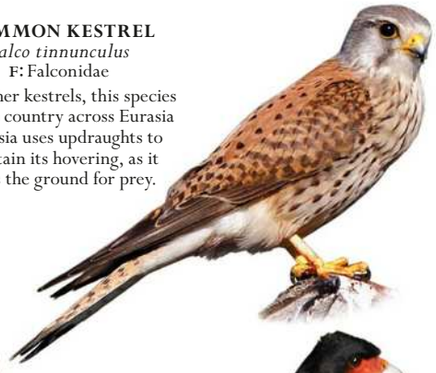
MERLIN
Falco columbarius
F: Falconidae

A nimble predator with a dashing flight, this falcon captures birds in mid-air over hills and moorland across the northern hemisphere.

23–30 cm
9–12 in

BAT FALCON
Falco rufigularis
F: Falconidae

This swift-flying American bird hunts birds, bats, and large insects at twilight. It is found from Mexico to Argentina.



32–39 cm
12½–15½ in

COMMON KESTREL
Falco tinnunculus
F: Falconidae

Like other kestrels, this species of open country across Eurasia and Asia uses updraughts to maintain its hovering, as it scans the ground for prey.

18–21 cm
7–8½ in

AFRICAN PYGMY FALCON
Polihierax semitorquatus
F: Falconidae

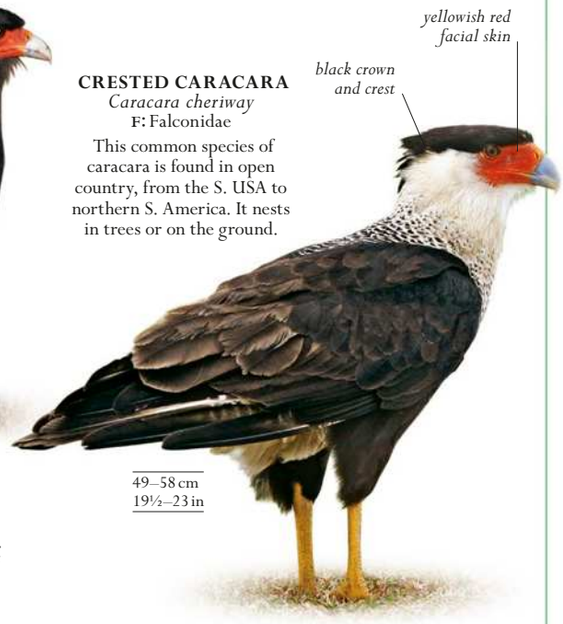
This African bird dives for insects and lizards on the ground. It breeds in the nests of weaver birds and may raise a brood co-operatively with others.

40–46 cm
16–18 in

48–53 cm
19–21 in

MOUNTAIN CARACARA
Phalcoboenus megalopterus
F: Falconidae

Relatives of falcons, caracaras are more sluggish and longer legged. Like other caracaras, this species of the high Andes is a scavenger, but also hunts small animals.



CRESTED CARACARA
Caracara cheriway
F: Falconidae

This common species of caracara is found in open country, from the S. USA to northern S. America. It nests in trees or on the ground.

49–58 cm
19½–23 in

53–62 cm
21–24 in

STRIATED CARACARA
Phalcoboenus australis
F: Falconidae

The tendency of this fearless caracara to attack newborn lambs has led to its persecution in its native Falkland Islands.

YELLOW-HEADED CARACARA
Milvago chimachima
F: Falconidae

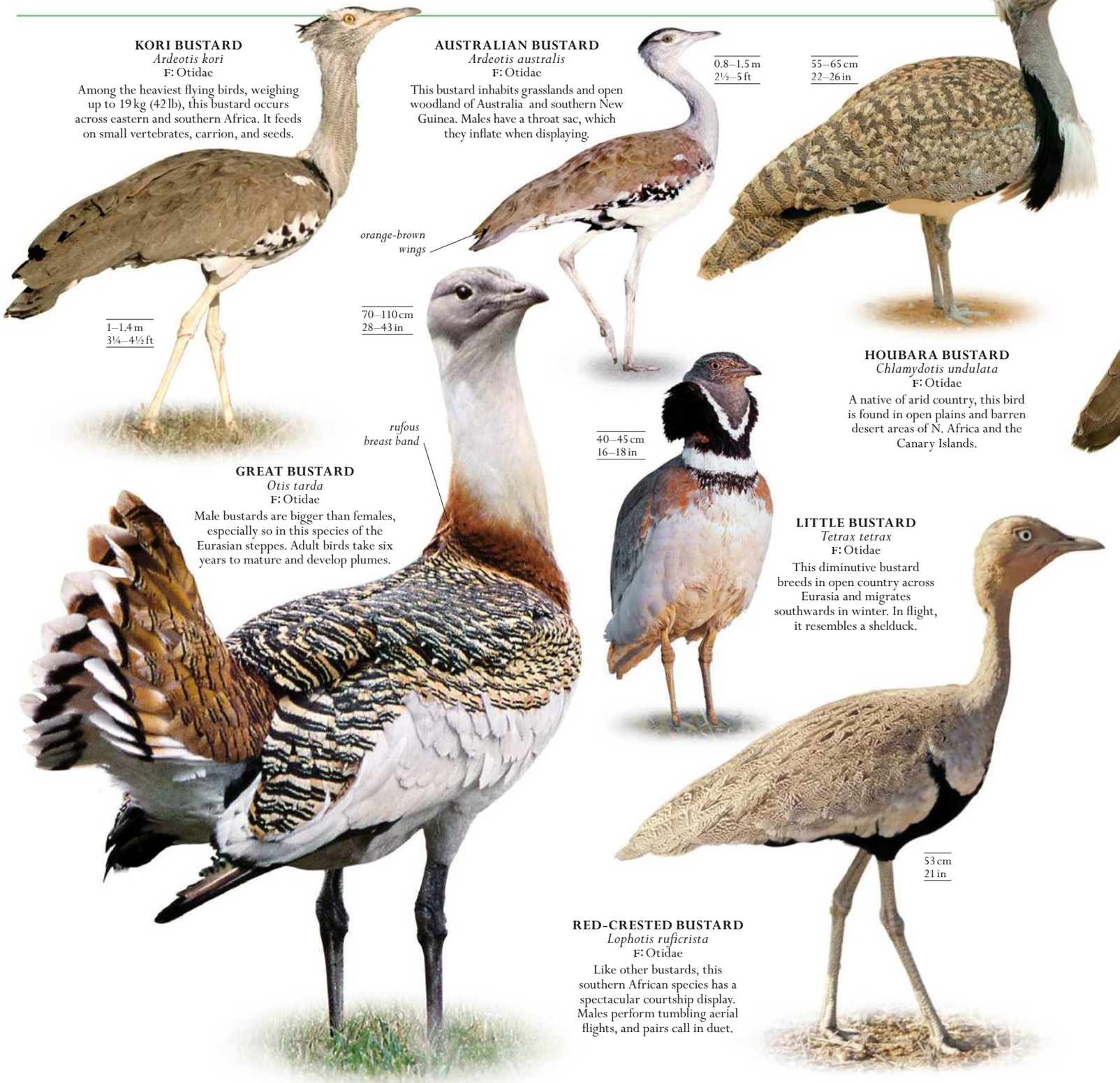
A hawk-like scavenger that also eats oil palm fruit, this bird of southern S. America frequents savanna and forest edges.

BUSTARDS

Bustards are medium to very large ground-living birds (including some of the heaviest flying birds) with long, stout legs but a short bill.

Birds in this order, the Otidiformes, have a steady, long-striding walk and pick insects, reptiles, small mammals, and vegetable matter from the ground in semi-deserts, open grasslands, and crops. In flight, they show large white areas on their long, broad wings. Larger species are powerful, steady fliers, while smaller ones have rapid wingbeats, looking more like small wildfowl or gamebirds with square-tipped wings. Social birds, they form flocks where numbers remain sufficiently high.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	OTIDIFORMES
FAMILIES	1
SPECIES	26



KORI BUSTARD
Ardeotis kori
F: Otidae

Among the heaviest flying birds, weighing up to 19 kg (42 lb), this bustard occurs across eastern and southern Africa. It feeds on small vertebrates, carrion, and seeds.

1–1.4 m
3¼–4½ ft

AUSTRALIAN BUSTARD
Ardeotis australis
F: Otidae

This bustard inhabits grasslands and open woodland of Australia and southern New Guinea. Males have a throat sac, which they inflate when displaying.

orange-brown wings

70–110 cm
28–43 in

0.8–1.5 m
2½–5 ft

55–65 cm
22–26 in

HOUBARA BUSTARD
Chlamydotis undulata
F: Otidae

A native of arid country, this bird is found in open plains and barren desert areas of N. Africa and the Canary Islands.

rufous breast band

GREAT BUSTARD
Otis tarda
F: Otidae

Male bustards are bigger than females, especially so in this species of the Eurasian steppes. Adult birds take six years to mature and develop plumes.

40–45 cm
16–18 in

LITTLE BUSTARD
Tetrax tetrax
F: Otidae

This diminutive bustard breeds in open country across Eurasia and migrates southwards in winter. In flight, it resembles a shelduck.

53 cm
21 in

RED-CRESTED BUSTARD
Lophotis ruficrista
F: Otidae

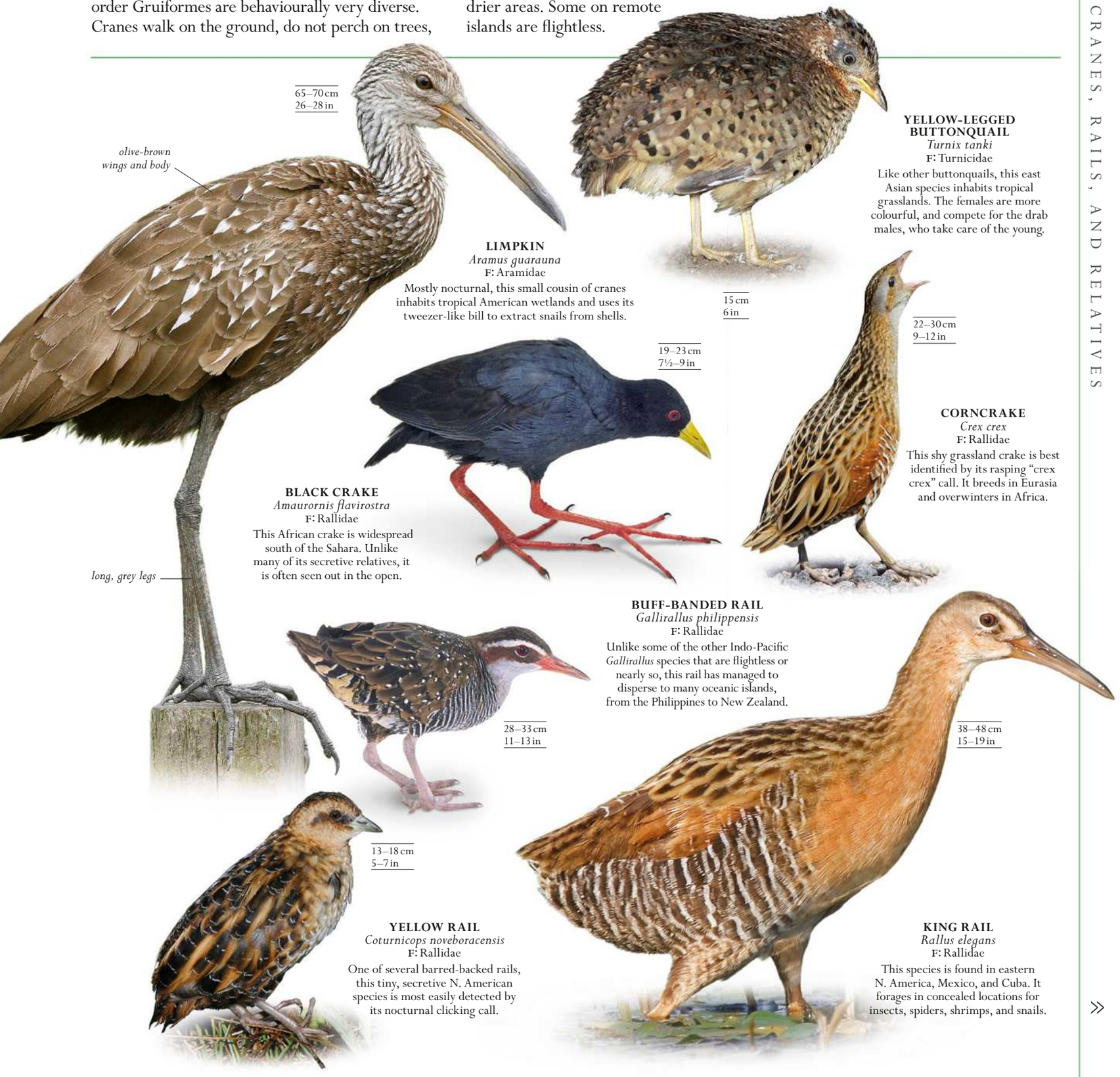
Like other bustards, this southern African species has a spectacular courtship display. Males perform tumbling aerial flights, and pairs call in duet.

CRANES, RAILS, AND RELATIVES

From graceful dancing cranes to small skulking rails, this order contains a wide variety of ground-dwelling birds of both dry and wetland habitats.

Mostly long-legged and long-billed, birds in the order Gruiformes are behaviourally very diverse. Cranes walk on the ground, do not perch on trees, and have short toes with the hind toe reduced or absent. The finfoots and coots have lobed, not webbed, feet. Rails and crakes have longer toes and a body that is deep but very slim, helping movement through dense vegetation, including reedbeds, in marshes or drier areas. Some on remote islands are flightless.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	GRUIFORMES
FAMILIES	6
SPECIES	188



LIMPKIN
Aramus guarauna
F: Aramidae
Mostly nocturnal, this small cousin of cranes inhabits tropical American wetlands and uses its tweezer-like bill to extract snails from shells.

YELLOW-LEGGED BUTTONQUAIL
Turnix tanki
F: Turnicidae
Like other buttonquails, this east Asian species inhabits tropical grasslands. The females are more colourful, and compete for the drab males, who take care of the young.

BLACK CRAKE
Amaurornis flavirostra
F: Rallidae
This African crake is widespread south of the Sahara. Unlike many of its secretive relatives, it is often seen out in the open.

CORNCRAKE
Crex crex
F: Rallidae
This shy grassland crake is best identified by its rasping "crex crex" call. It breeds in Eurasia and overwinters in Africa.

BUFF-BANDED RAIL
Gallirallus philippensis
F: Rallidae
Unlike some of the other Indo-Pacific *Gallirallus* species that are flightless or nearly so, this rail has managed to disperse to many oceanic islands, from the Philippines to New Zealand.

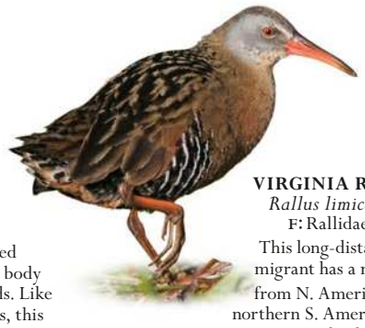
YELLOW RAIL
Coturnicops noveboracensis
F: Rallidae
One of several barred-backed rails, this tiny, secretive N. American species is most easily detected by its nocturnal clicking call.

KING RAIL
Rallus elegans
F: Rallidae
This species is found in eastern N. America, Mexico, and Cuba. It forages in concealed locations for insects, spiders, shrimps, and snails.

23–28 cm
9–11 in

WATER RAIL
Rallus aquaticus
F: Rallidae

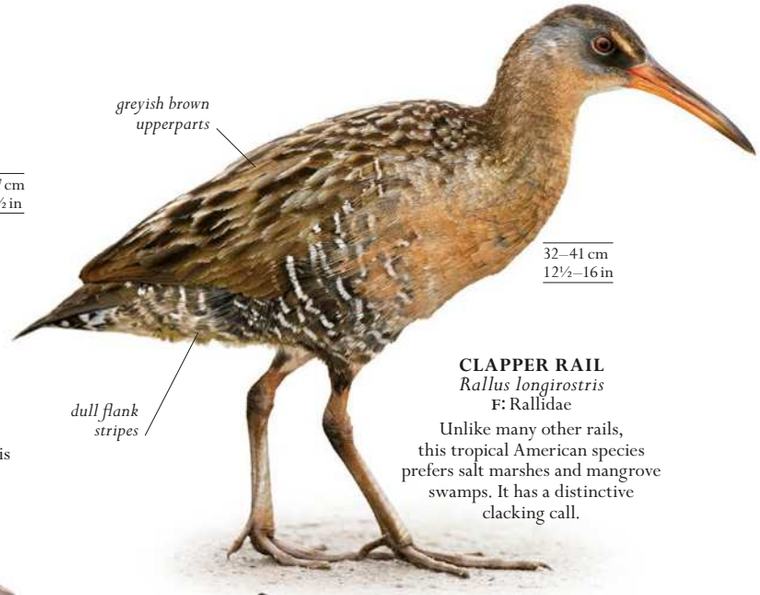
Rallus rails are long-billed marsh birds with a narrow body for passing through reed beds. Like other members of the genus, this Eurasian bird is rarely seen away from dense cover.



20–27 cm
8–10½ in

VIRGINIA RAIL
Rallus limicola
F: Rallidae

This long-distance migrant has a range from N. America to northern S. America. It is a secretive bird that is difficult to spot.



32–41 cm
12½–16 in

CLAPPER RAIL
Rallus longirostris
F: Rallidae

Unlike many other rails, this tropical American species prefers salt marshes and mangrove swamps. It has a distinctive clacking call.

39–40 cm
15½–16 in

AMERICAN COOT
Fulica americana
F: Rallidae

Found from N. America to northern S. America, this bird, unlike true rails, lives on water. It forages in shallow water and feeds on land.

26–33 cm
10–13 in

SUNGREBE
Heliornis fulica
F: Heliornithidae

This species is a tropical American finfoot. Like all finfoots, it is a secretive bird of slow-moving water, where it feeds on small animals.

21–27 cm
8½–10½ in

RUDDY-BREASTED CRAKE
Porzana fusca
F: Rallidae

This crake occurs in wetlands of eastern Asia, but is also seen in mangroves or drier habitats. It has distinctive chestnut-coloured underparts.

30–36 cm
12–14 in

PURPLE GALLINULE
Porphyrio martinica
F: Rallidae

Occurring in tropical American marshes, this species belongs to a group of rails called swamphens. It is characterized by blue-purple plumage and a blue forehead shield.

20–25 cm
8–10 in

SORA RAIL
Porzana carolina
F: Rallidae

This crake is the commonest N. American member of the rail family. It breeds in shallow wetland and overwinters in the Caribbean.

18–22 cm
7–9 in

WHITE-BROWED CRAKE
Porzana cinerea
F: Rallidae

Shorter bills and distinctive calls distinguish crakes from rails. This grey-fronted bird is a typical *Porzana* crake. Its range extends from the Malay Peninsula to Polynesia.

32–35 cm
12½–14 in

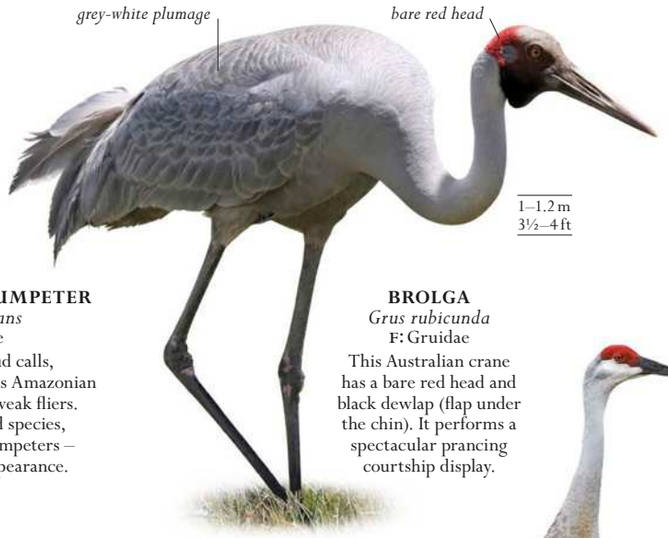
COMMON MOORHEN
Gallinula chloropus
F: Rallidae

Moorhens are noisy birds with dark plumage and jerky movements. One of several *Gallinula* species, this one has an almost global distribution.

48–56 cm
19–22 in

GREY-WINGED TRUMPETER
Psophia crepitans
F: Psophiidae

Named for their loud calls, trumpeters are gregarious Amazonian ground birds that are weak fliers. This is a black-bodied species, which – like other trumpeters – has a "hunchback" appearance.



1–1.2 m
3½–4 ft

BROLGA
Grus rubicunda
F: Gruidae

This Australian crane has a bare red head and black dewlap (flap under the chin). It performs a spectacular prancing courtship display.

1–1.1 m
3 ¼–3½ ft

BLUE CRANE
Anthropoides paradiseus
F: Gruidae

The long wing plumes of this African crane resemble a tail. When not breeding, it is nomadic, frequenting lakeside, grassland, and farmland.

1.4–1.5 m
4½–5 ft

RED-CROWNED CRANE
Grus japonensis
F: Gruidae

Declining in numbers, this bird breeds in Siberia and overwinters in Korea and China. The heaviest of all cranes, like related species, it has a bare, red crown patch.

GREY CROWNED CRANE
Balearica regulorum
F: Gruidae

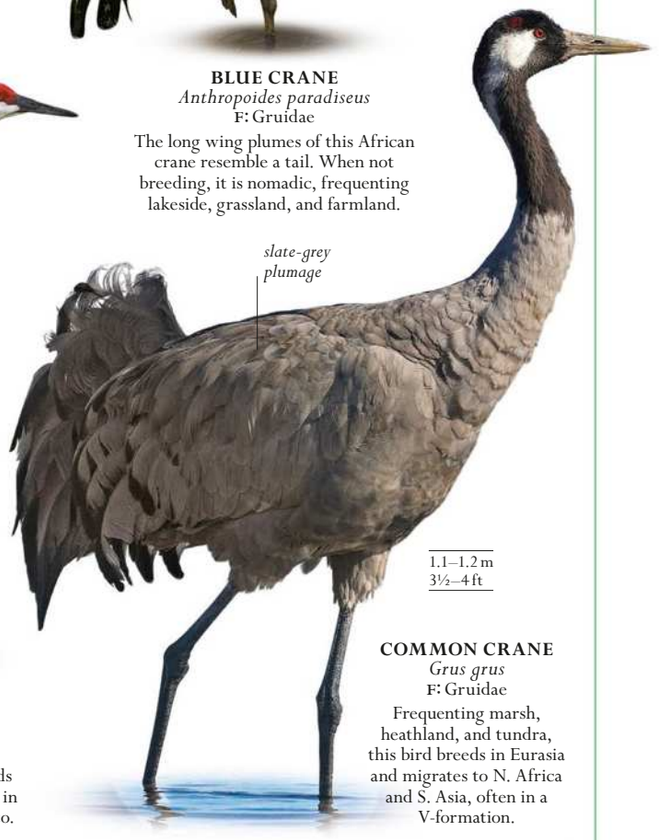
African crowned cranes are the only cranes that can grip branches, enabling them to roost in trees. This is the most southerly species.

1.1 m
3½ ft

1.1–1.2 m
3½–4 ft

SANDHILL CRANE
Grus canadensis
F: Gruidae

A N. American crane, this species also reaches westwards into Siberia. It migrates south in family groups, as far as Mexico.



1.1–1.2 m
3½–4 ft

COMMON CRANE
Grus grus
F: Gruidae

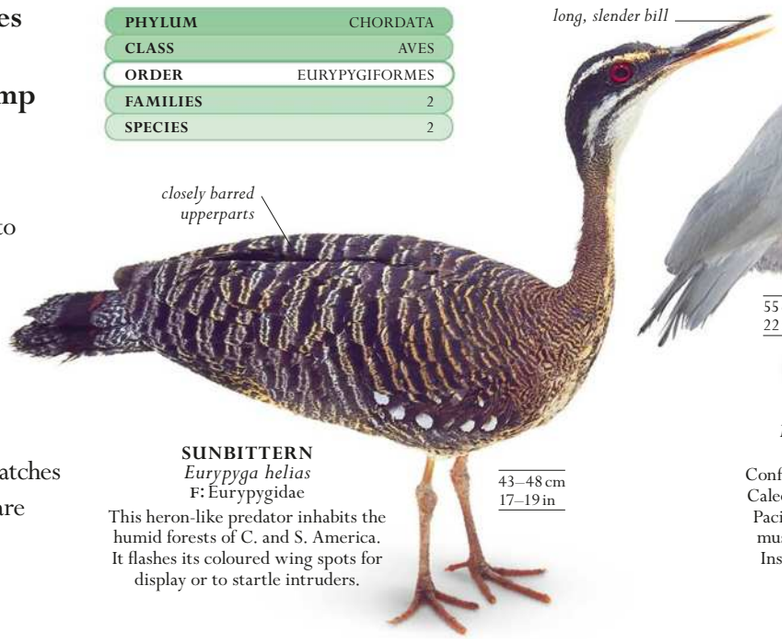
Frequenting marsh, heathland, and tundra, this bird breeds in Eurasia and migrates to N. Africa and S. Asia, often in a V-formation.

KAGU AND SUNBITTERN

Recently separated from the cranes and rails, the tropical kagu and sunbittern are unique birds of damp forest, limited to very restricted geographical ranges.

A handful of species worldwide are difficult to place in a relationship with others: these two appear to be closely related, but look very different. Their position in the evolutionary tree is still controversial. The kagu reveals broad grey and white bands across its wings, when they are spread in courtship displays. The sunbittern likewise shows unexpected patches of colour on its upper wings and tail, which are fanned horizontally to create a single, broad pattern when it is displaying.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	EURYPYGIFORMES
FAMILIES	2
SPECIES	2



43–48 cm
17–19 in

SUNBITTERN
Eurypyga helias
F: Eurypygidae

This heron-like predator inhabits the humid forests of C. and S. America. It flashes its coloured wing spots for display or to startle intruders.

55 cm
22 in

KAGU
Rhynochetos jubatus
F: Rhynochetidae

Confined to the forests of New Caledonia in the southwestern Pacific, the kagu lacks strong muscles necessary for flight. Instead, it uses its wings to glide and for display.

juveniles lose their buff face feathers as they mature, leaving a patch of white cheek skin
red throat sac
neck feathers lack interlocking barbs, giving a loose, "hairy" appearance

^ CROWN AND COLOUR
This species sports a bristly golden crown, a neat black forehead, and bare white cheeks, edged with a patch of red, which is broader in East African birds. Both males and females have a red throat sac that can be inflated with air, then rapidly deflated to give a booming call.

GREY CROWNED CRANE

Balearica regulorum

Grey crowned cranes belong to the Gruidae family of birds, famous for their choreography; for these birds, dance is an important part of life. On the open savanna they display by jumping, flapping their wings, and bowing – sometimes, it seems, just to relieve aggression or reinforce pair-bonding – but mainly to court their mate by flaunting their elaborate head ornamentation. They lack the long, coiled windpipe of the longer-billed crane species, so instead of calling like a bugle they honk like a goose. They also boom during courtship by puffing air from an inflated red throat sac. During the breeding season pairs retire to wetter habitats, where thicker vegetation conceals their nest – a circular platform made from grasses and sedges. Here, the chicks are hidden from predators, allowing the parents to roost, uniquely for cranes, perched high in trees.

SIZE 1.1 m (3½ ft)
HABITAT Open country
DISTRIBUTION E. and S. Africa
DIET Grasses, seeds, invertebrates, small vertebrates

black head feathers give the appearance of a bulging forehead
nostril
bill is shorter and stouter than in other crane species

THIRD EYELID >
Also known as a nictitating membrane, from the Latin *nictare*, meaning "to blink", this translucent eyelid – the same as in other birds – moves across the eye to clean its surface.

GOLDEN PLUMES >
When the wings are folded, long, golden feathers on the upper wings – just above the flight feathers – hang down over the side of the body.

RUFFLED NECK <
Long, tapered contour feathers give the crowned crane a shaggy appearance around the upper part of the body and the lower part of the neck. Most of the bird's plumage is grey.

FEET AND CLAWS >
Crowned cranes have long hind toes, setting them apart from other crane species. This enables them to perch in trees – perhaps a vestige of tree-dwelling ancestors.

LONG LEGS ^
Although long legs help in dancing displays, and are good for wading, crowned cranes have shorter legs than those of other crane species.

WING ^
When crowned cranes fly overhead, their white under-wing patches are clearly visible. Although strong-winged, these tropical birds – unlike other cranes – do not sustain long-distance migrations.

WADERS, GULLS, AND AUKS

Largely birds of coastal areas, waders are diverse in form and habit. Many are adapted for feeding in mud and water, with long legs and a probing bill.

The birds collectively known as waders, or Charadriiformes, fall into three main groups. Of these, two groups are made up of shorebirds. Plovers and allied species are mostly short-legged, short-billed birds that feed on small invertebrates found close to the surface of the ground. Some birds in this group, such as lapwings, favour drier habitats inland. Other species in the plover group are more adapted to wetland. Stilts and avocets sweep shallow water with their needle-like bill, while oystercatchers use their long stout bill for opening mollusc shells. In the group consisting of sandpipers, snipe, and allies, the birds use their long bill to probe deep mud. Some of their relatives, such as shanks and curlews, have long legs, too, and so can wade into deeper water to feed.

OCEANIC BIRDS

The final group in this order is made up of gulls, terns, skuas, and auks – web-footed birds that are the most ocean-going of the order. They may spend much of their lives at sea and some travel immense distances on migration. Gulls are opportunistic predators that are also seen foraging far inland. Auks, distributed around the Arctic, are specialized for diving for ocean-swimming prey. Their black and white coloration gives them a superficial resemblance to penguins, but they are not close relatives.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CHARADRIIFORMES
FAMILIES	19
SPECIES	383

DEBATE

ORIGIN OF A GULL

New species appear when populations diverge too much to interbreed with others. In this way it was thought that European herring gulls diverged from Asian ancestors that spread eastwards to encircle the Arctic. Recent evidence suggests herring gulls descended from gulls isolated in the North Atlantic.

40–44 cm
16–17½ in

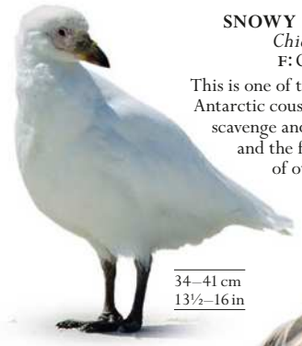
EURASIAN STONE CURLEW
Burhinus oedicnemus
F: Burhinidae

Named after their shrill curlew-like calls, the mostly nocturnal stone curlews are related to plovers. This widespread Eurasian species occurs in dry mudflats inland.

49–55 cm
19½–22 in

GREAT STONE CURLEW
Esacus recurvirostris
F: Burhinidae

Large *Esacus* stone curlews have a chisel-like bill for hunting prey, such as crabs, near water. This is a S. Asian species.



34–41 cm
13½–16 in

SNOWY SHEATHBILL
Chionis albus
F: Chionidae

This is one of two white sheathbills, Antarctic cousins of plovers, which scavenge and consume carrion and the food and young of other birds.

38–41 cm
15–16 in

IBISBILL
Ibidorhyncha struthersii
F: Ibidorhynchidae

The only plover relative with a long, down-curved bill, this bird plucks invertebrates from stony riverbeds in mountains of C. Asia.

20–22 cm
8–9 in

MAGELLANIC PLOVER
Pluvianellus socialis
F: Chionidae

This unusual S. American wader – the only one to regurgitate food for chicks – is more closely related to sheathbills than other plovers.

42–47 cm
16½–18½ in

AMERICAN BLACK OYSTERCATCHER
Haematopus bachmani
F: Haematopodidae

Black oystercatchers generally have more restricted ranges than pied (having two or more colours) species. This species is confined to the west coast of N. America.

40–45 cm
16–18 in

EURASIAN OYSTERCATCHER
Haematopus ostralegus
F: Haematopodidae

The most widespread oystercatcher, this pied species breeds in N. Eurasia. Like others, it uses its long bill to open bivalve molluscs.

33–40 cm
13–16 in

CRAB PLOVER
Dromas ardeola
F: Dromadidae

The crab plover may be more closely related to gulls than to true plovers. Found around Indian Ocean coastlines, it uses its stout bill for eating crabs.

needle-like bill

36–45 cm
14–16 in

BANDED STILT
Cladorhynchus leucocephalus
F: Recurvirostridae

Stilts hunt small swimming invertebrates. This Australian species gathers in large flocks on salt lakes to feed on brine shrimp.

40–46 cm
16–18 in

RED-NECKED AVOCET
Recurvirostra novaehollandiae
F: Recurvirostridae

A nomadic bird of Australian wetlands, this distinctively marked wader is a sociable species that feeds in large flocks.

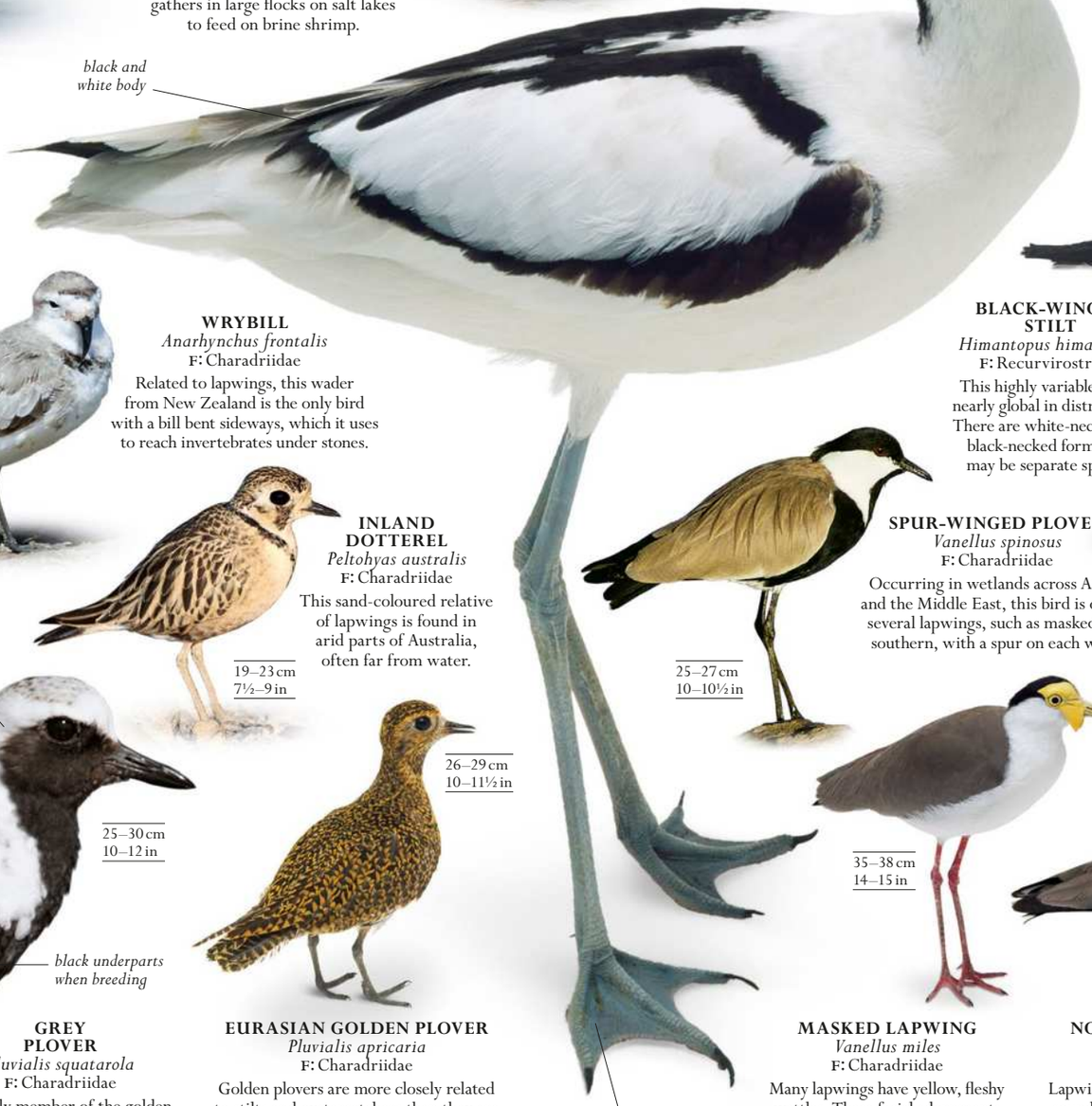
upturned bill

42–45 cm
16½–18 in

PIED AVOCET
Recurvirostra avosetta
F: Recurvirostridae

This Eurasian wader is typical of avocets: relatives of stilts that take small aquatic animals by sweeping their upturned bill through water.

black and white body



20 cm
8 in

WRYBILL
Anarhynchus frontalis
F: Charadriidae

Related to lapwings, this wader from New Zealand is the only bird with a bill bent sideways, which it uses to reach invertebrates under stones.

33–36 cm
13–14 in

BLACK-WINGED STILT
Himantopus himantopus
F: Recurvirostridae

This highly variable stilt is nearly global in distribution. There are white-necked and black-necked forms that may be separate species.

19–23 cm
7½–9 in

INLAND DOTTEREL
Peltohyas australis
F: Charadriidae

This sand-coloured relative of lapwings is found in arid parts of Australia, often far from water.

25–27 cm
10–10½ in

SPUR-WINGED PLOVER
Vanellus spinosus
F: Charadriidae

Occurring in wetlands across Africa and the Middle East, this bird is one of several lapwings, such as masked and southern, with a spur on each wing.

white crown

25–30 cm
10–12 in

black underparts when breeding

GREY PLOVER
Pluvialis squatarola
F: Charadriidae

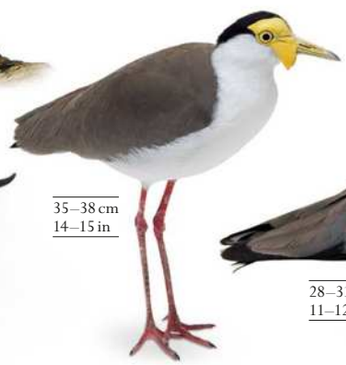
The only member of the golden plover group with grey, not yellow, speckled upperparts, this species breeds around Arctic coastal tundra.

26–29 cm
10–11½ in

EURASIAN GOLDEN PLOVER
Pluvialis apricaria
F: Charadriidae

Golden plovers are more closely related to stilts and oystercatchers than they are to other plovers. This species develops a black belly when breeding.

blue-grey feet and legs



35–38 cm
14–15 in

MASKED LAPWING
Vanellus miles
F: Charadriidae

Many lapwings have yellow, fleshy wattles. These facial adornments are especially prominent on this bird from Australasia.

28–31 cm
11–12 in

NORTHERN LAPWING
Vanellus vanellus
F: Charadriidae

Lapwings are named for the lapping sound of their flight. This Eurasian species has a distinctive, pointed crest. It is also called a peewit for its unique call.

18–20 cm
7–8 in

COMMON RINGED PLOVER
Charadrius hiaticula
F: Charadriidae

One of the most widespread ring-necked plovers, this species breeds around the Arctic and overwinters in Africa and S.W. Asia.

23–27 cm
9–10½ in

KILLDEER
Charadrius vociferus
F: Charadriidae

This long-tailed, grassland plover migrates between N. and S. America, but there are resident populations in Peru and Chile.

20–22 cm
8–9 in

EURASIAN DOTTEREL
Charadrius morinellus
F: Charadriidae

Females of this tundra-breeding bird are more brightly coloured than males, but like many other plovers both become duller in winter.

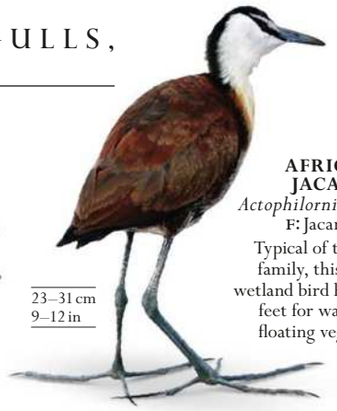
»

» WADERS, GULLS, AND AUKS

28–31 cm
11–12 in

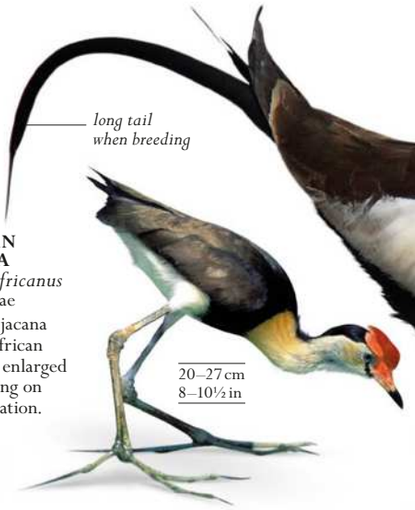
BRONZE-WINGED JACANA
Metopidius indicus
F: Jacanidae

This species is widespread across India and S.E. Asia. Males have a flattened "forearm" bone that helps them lift chicks with their wings.


23–31 cm
9–12 in

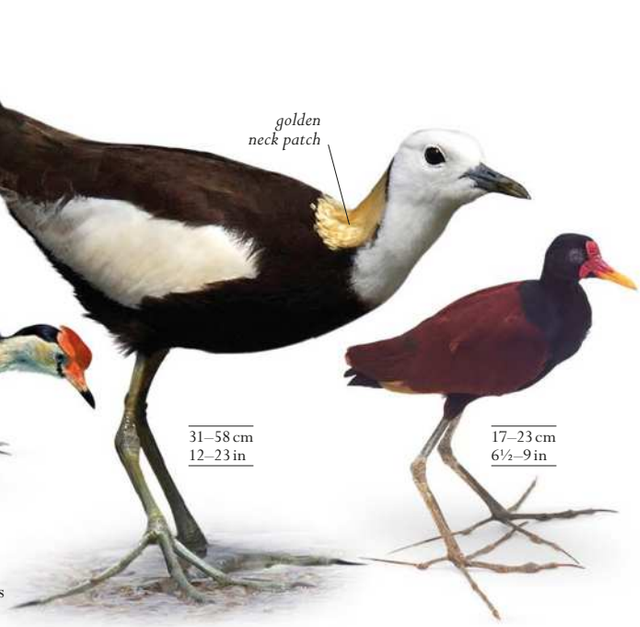
AFRICAN JACANA
Actophilornis africanus
F: Jacanidae

Typical of the jacana family, this African wetland bird has enlarged feet for walking on floating vegetation.


long tail when breeding
20–27 cm
8–10½ in

COMB-CRESTED JACANA
Irediparra gallinacea
F: Jacanidae

Found from Asia to Australia, this species is named for its fleshy head wattle. As with other jacanas, males incubate the eggs and care for the young.


golden neck patch
31–58 cm
12–23 in

PHEASANT-TAILED JACANA
Hydrophasianus chirurgus
F: Jacanidae

This southern Asian spur-winged jacana is the only species that changes plumage – losing its long tail – outside the breeding season.

17–23 cm
6½–9 in

WATTLED JACANA
Jacana jacana
F: Jacanidae

The dominant female of this S. American species breeds with many males, perhaps to compensate for crocodile predation of eggs.

♀
15–19 cm
6–7½ in

PLAINS WANDERER
Pedionomus torquatus
F: Pedionomidae

This quail-like bird of Australian grassland – the only member of its family – is actually related to the wetland jacanas.

23–26 cm
9–10 in

GREATER PAINTED-SNIPE
Rostratula benghalensis
F: Rostratulidae

Related to the jacanas, the short-legged painted-snipes share their female-dominant mating system. This bird is from Old World tropical wetlands.

23–25 cm
9–10 in

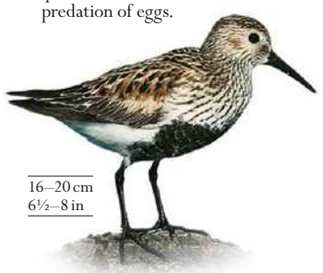
SHORT-BILLED DOWITCHER
Limnodromus griseus
F: Scolopacidae

Dowitchers are related to snipes and are reddish coloured in their breeding plumage. The short-billed dowitcher is confined to the Americas.

23–25 cm
9–10 in

RED KNOT
Calidris canutus
F: Scolopacidae

Like many migratory waders, the Arctic-breeding red knot moults its distinctive summer plumage to more drab colours in winter.


16–20 cm
6½–8 in

DUNLIN
Calidris alpina
F: Scolopacidae

Globally common, the dunlin is typical of waders that breed around the Arctic and flock to the warmer south in the winter.

17–19 cm
6½–7½ in

JACK SNIPE
Lymnocryptes minimus
F: Scolopacidae

Birds of the snipe-woodcock group have a long bill, short legs, and are camouflaged by their plumage. This Old World bird is the smallest in this group.

25–27 cm
10–10½ in

COMMON SNIPE
Gallinago gallinago
F: Scolopacidae

Typical of waders, chicks of this globally widespread species are active soon after hatching. Unlike other waders, snipes feed their chicks.

long, slightly upturned bill
rufous (reddish) underparts during breeding
black and white upperparts
37–42 cm
14½–16½ in

HUDSONIAN GODWIT
Limosa haemastica
F: Scolopacidae

This is one of two American godwits, and is named after its breeding habitat, which includes the shores of Hudson Bay.

20–21 cm
8–8½ in

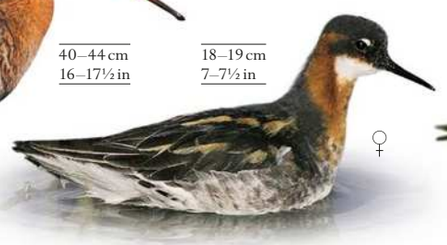
SANDERLING
Calidris alba
F: Scolopacidae

This sandpiper breeds within the Arctic Circle, further north than other waders. In winter, it flocks on sandy shores further south.

40–44 cm
16–17½ in

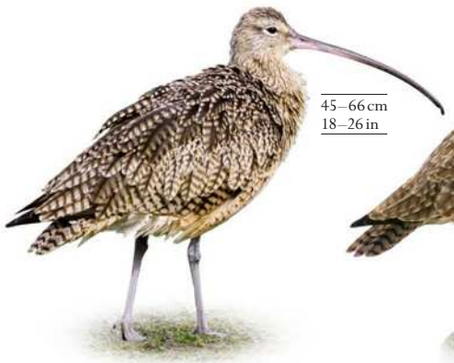
BLACK-TAILED GODWIT
Limosa limosa
F: Scolopacidae

Typical of godwits, this Old World species has a slightly upturned bill. It ranges far inland to forage on grassland, heath, and pasture.


♀
18–19 cm
7–7½ in

RED-NECKED PHALAROPE
Phalaropus lobatus
F: Scolopacidae

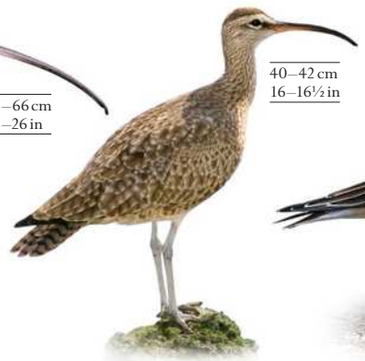
This species has a breeding range that includes much of the Arctic region. Females are brightly coloured and attract males with displays during breeding; males care for offspring.



45–66 cm
18–26 in

LONG-BILLED CURLEW
Numenius americanus
F: Scolopacidae

A typical curlew, this American species is a large wader with a long, down-curved bill for probing deeply in mud for invertebrate prey.



40–42 cm
16–16½ in

WHIMBREL
Numenius phaeopus
F: Scolopacidae

A mid-sized curlew, the whimbrel has a distinctive trilling call and breeds in circumpolar regions. Some individuals winter as far away as Australia.

18–20 cm
7–8 in

BUFF-BREASTED SANDPIPER
Tryngites subruficollis
F: Scolopacidae

This wader breeds in the tundra of N. America and extreme E. Siberia. It winters in the grasslands of S. America.

27–29 cm
10½–11½ in

COMMON REDSHANK
Tringa totanus
F: Scolopacidae

Most waders breed near fresh water, but the Old World common redshank – named after its coloured legs – may sometimes breed on salt marshes.

23–25 cm
9–10 in

LESSER YELLOWLEGS
Tringa flavipes
F: Scolopacidae

Yellowlegs belong to the shank group. This species breeds in forests in Alaska and Canada, and overwinters in the Caribbean.

large neck ruff in breeding male

20–30 cm
8–12 in

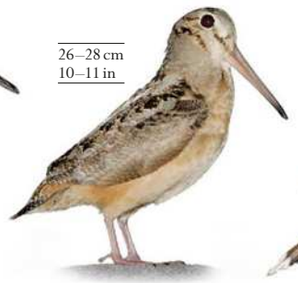
RUFF
Calidris pugnax
F: Scolopacidae

Males of this Old World marsh and meadow species transform during breeding: they lose their grey winter plumage and take on a rufous (reddish brown) and black coloration, with a showy neck ruff.

26–30 cm
10–12 in

WANDERING TATTLER
Tringa incana
F: Scolopacidae

This shank species breeds in Alaska, during which its breast is barred. It winters further south along the Pacific coastline of America.



26–28 cm
10–11 in

AMERICAN WOODCOCK
Scolopax minor
F: Scolopacidae

Like other woodcocks and snipes, this American bird is superbly camouflaged and its eyes are placed high, enabling all-round vision for predators.

18–20 cm
7–8 in

black-spotted chest and belly in summer

reddish legs

SPOTTED SANDPIPER
Actitis macularius
F: Scolopacidae

Like the related common sandpiper (*A. hypoleucos*) from Eurasia, this American sandpiper has a short bill for pecking food from dry ground.

22–24 cm
9–9½ in

RUDDY TURNSTONE
Arenaria interpres
F: Scolopacidae

This bird, which breeds across the northern hemisphere, is named for the way it flips objects to search for prey.

14–16 cm
5½–6½ in

SPOON-BILLED SANDPIPER
Calidris pygmaea
F: Scolopacidae

Like spoonbills, this wader from E. Asia uses its distinctive spoon-like bill to sweep shallow water for invertebrate prey.

27–29 cm
10½–11½ in

WHITE-BELLIED SEEDSNIPE
Attagis malouinus
F: Thinocoridae

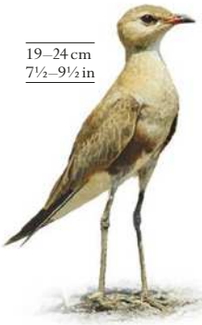
Four species of short-billed, herbivorous seedsnipe live in the open habitats of S. America. This species is confined to the southern tip.

»

19–21 cm
7½–8½ in

CREAM-COLOURED COURSER
Cursorius cursor
F: Glareolidae

Often nocturnal, coursers are inconspicuous, long-legged ground birds, similar to plovers. This is a migratory species from Asia and Africa.



19–24 cm
7½–9½ in

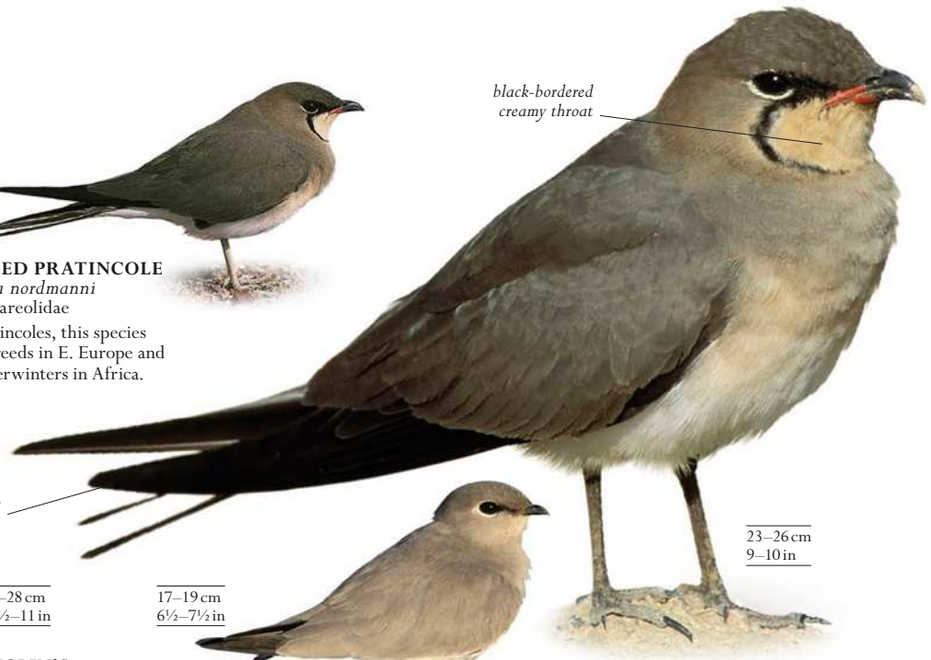
AUSTRALIAN PRATINCOLE
Stiltia isabella
F: Glareolidae

This pratincole from Australia and Indonesia usually stays close to fresh water, but has special glands that enable it to drink salt water too.

24–28 cm
9½–11 in

BLACK-WINGED PRATINCOLE
Glareola nordmanni
F: Glareolidae

Like other pratincoles, this species is migratory. It breeds in E. Europe and C. Asia and overwinters in Africa.



23–26 cm
9–10 in

17–19 cm
6½–7½ in

LITTLE PRATINCOLE
Glareola lactea
F: Glareolidae

This small species is from S. Asia. Like its relatives, the little pratincole feeds on insects in flight. It has a forked tail.

COLLARED PRATINCOLE
Glareola pratincola
F: Glareolidae

Like most pratincoles, this species from S. Europe and Africa gathers in large, noisy flocks on open wetlands.

27–28 cm
10½–11 in

HEUGLIN'S COURSER
Rhinoptilus cinctus
F: Glareolidae

Most coursers are restricted to arid deserts and scrub, but this African species also ventures into woodland habitats.

50–60 cm
20–23½ in

SWALLOW-TAILED GULL
Creagrus furcatus
F: Laridae

The only nocturnal gull, this species breeds on the Galapagos Islands and overwinters in S. America. It feeds on fish and squid.

42–44 cm
16½–17½ in

DOLPHIN GULL
Leucophaeus scoresbii
F: Laridae

This gull is famously aggressive to other birds. It is confined to the southern tip of S. America and the Falkland Islands.

36–41 cm
14–16 in

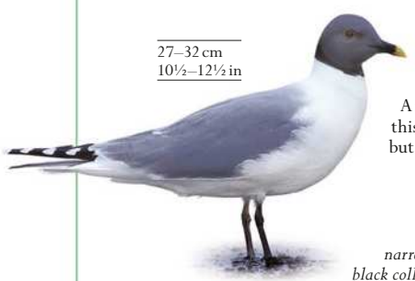
LAUGHING GULL
Leucophaeus atricilla
F: Laridae

An American hooded gull, this species has a laughing call. It is a colonial breeder on coastal estuaries and salt marshes.

45–47 cm
18–18½ in

GREY GULL
Leucophaeus modestus
F: Laridae

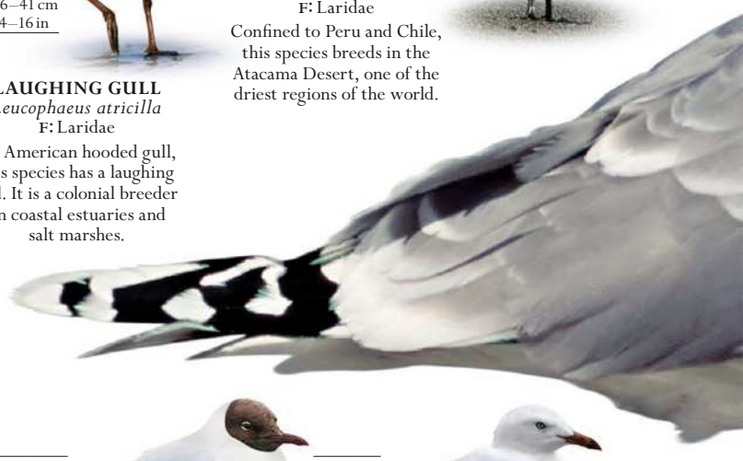
Confined to Peru and Chile, this species breeds in the Atacama Desert, one of the driest regions of the world.



27–32 cm
10½–12½ in

SABINE'S GULL
Xema sabini
F: Laridae

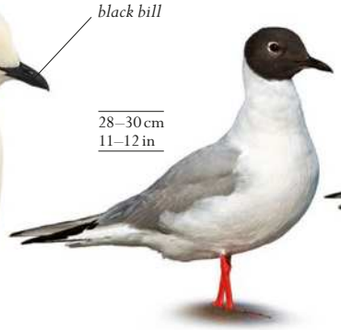
A relative of the ivory gull, this bird is an Arctic breeder, but it migrates huge distances to overwinter in S. America and Africa.



38–40 cm
15–16 in

ROSS'S GULL
Rhodostethia rosea
F: Laridae

A distinctive pink gull, Ross's gull breeds in swampy and wooded Arctic tundra, and winters along coasts and at sea.



28–30 cm
11–12 in

BONAPARTE'S GULL
Chroicocephalus philadelphia
F: Laridae

A N. American masked gull, this species breeds in wet coniferous forests in Canada and winters along Caribbean coasts.

34–37 cm
13½–14½ in

COMMON BLACK-HEADED GULL
Chroicocephalus ridibundus
F: Laridae

Like other members of the masked gull group, this dark-headed gull becomes white headed in winter. It is abundant in the northern hemisphere.

40–45 cm
16–18 in

SILVER GULL
Chroicocephalus novaehollandiae
F: Laridae

Despite its different appearance, this Australian gull is related to the common black-headed gull. It visits human refuse sites to feed.

40–42 cm
16–16½ in

MEW GULL
Larus canus
F: Laridae

This northern hemisphere species, whose name derives from its distinctive call, is also called the common gull. It breeds inland on moors, as well as on the coast.

50–67 cm
20–26 in

PACIFIC GULL
Larus pacificus
F: Laridae

Belonging to a group of southern gulls with banded tails, this large-billed Australian species cracks open shellfish by dropping them on rocks.

55–66 cm
22–26 in

WESTERN GULL
Larus occidentalis
F: Laridae

This large gull is found on the Pacific coast of N. America. It nests in colonies, usually offshore on islands or rocks.

64–78 cm
25–31 in

GREAT BLACK-BACKED GULL
Larus marinus
F: Laridae

The world's largest gull, this North Atlantic coastal bird is an aggressive predator and preys on other seabirds and their chicks.

GREAT BLACK-HEADED GULL
Ichthyaetus ichthyaetus
F: Laridae

One member of an Asian group of black-headed gulls, this species breeds in Russia and overwinters on Mediterranean and Indian ocean coasts. It is also known as Pallas's gull.

62–68 cm
24–27 in

GLAUCOUS GULL
Larus hyperboreus
F: Laridae

A large, Arctic-breeding species, this coastal gull is much paler than most related white-headed gulls found in the northern hemisphere.

46–51 cm
18–20 in

RING-BILLED GULL
Larus delawarensis
F: Laridae

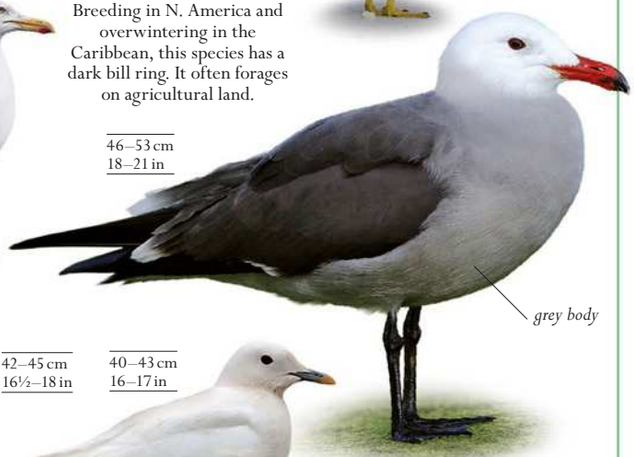
Breeding in N. America and overwintering in the Caribbean, this species has a dark bill ring. It often forages on agricultural land.

57–61 cm
22½–24 in

52–60 cm
20½–23½ in

HERRING GULL
Larus argentatus
F: Laridae

Related to the lesser black-backed gull (*L. fuscus*), this species is often seen in coastal towns in Europe and eastern N. America.



46–53 cm
18–21 in

42–45 cm
16½–18 in

SOOTY GULL
Ichthyaetus hemprichii
F: Laridae

As with many warm-region gulls, this species from Asia and Africa has dark plumage, which may have evolved as an adaptation to strong sunshine.

40–43 cm
16–17 in

IVORY GULL
Pagophila eburnea
F: Laridae

This Arctic gull is rarely found far from pack ice. It follows polar bears to scavenge at their kills.

HEERMANN'S GULL
Larus heermanni
F: Laridae

This dark gull from N. America is actually related to northern white-headed gulls. It often forages with brown pelicans and steals their food.

39–43 cm
15½–17 in

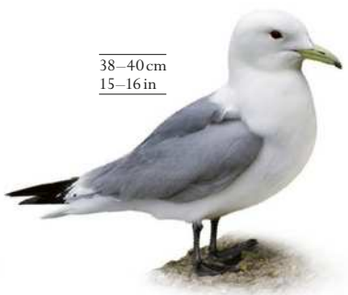
WHITE-EYED GULL
Ichthyaetus leucophthalmus
F: Laridae

This relative of the sooty gull is confined to the Red Sea region, where it is threatened by oil spills.

35–40 cm
14–16 in

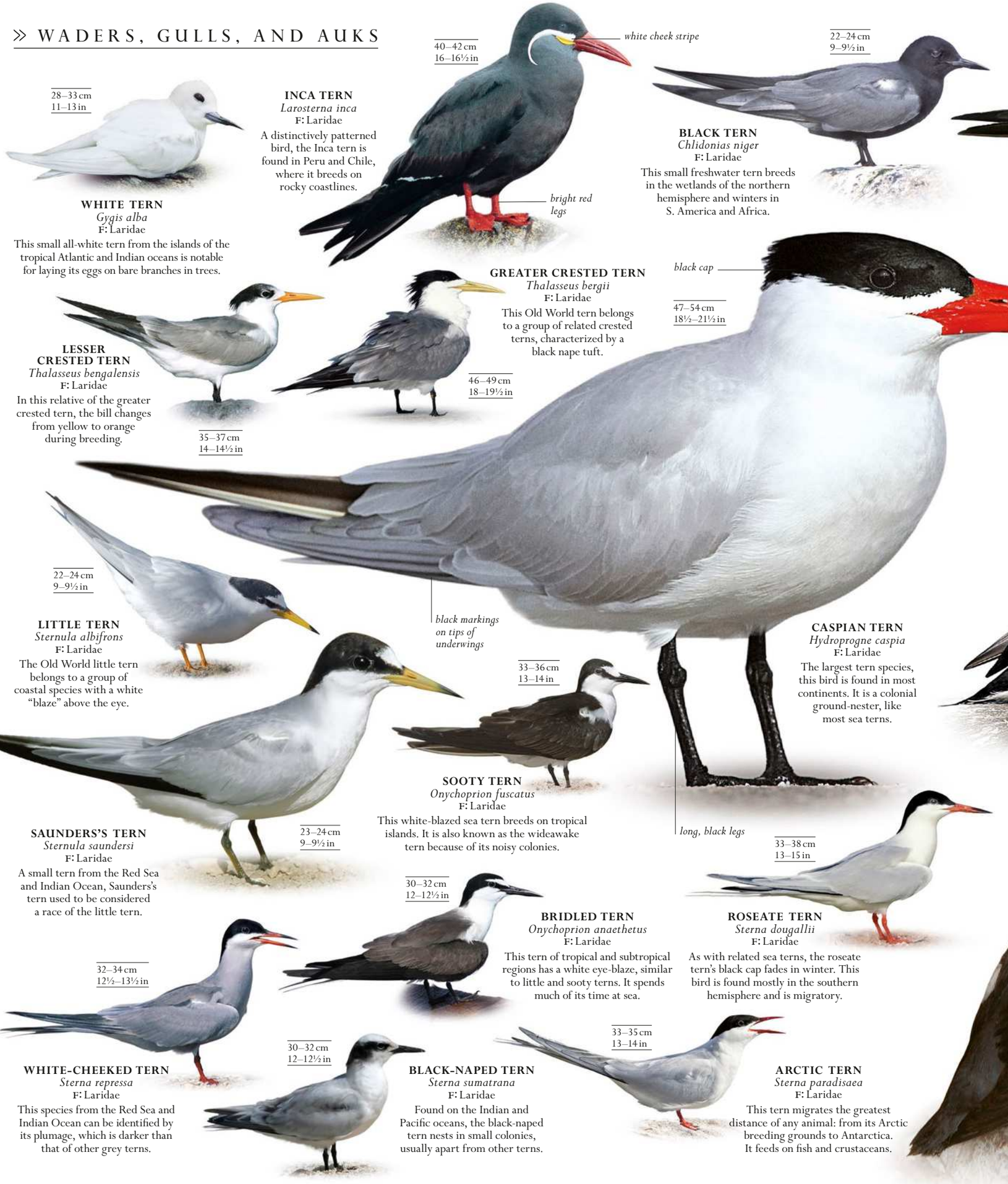
RED-LEGGED KITTIWAKE
Rissa brevirostris
F: Laridae

This kittiwake breeds only on islands in the Bering Sea in the North Pacific and spends winter at sea further south.


38–40 cm
15–16 in

BLACK-LEGGED KITTIWAKE
Rissa tridactyla
F: Laridae

The world's most abundant species of gull, this colonial cliff-nesting bird is found in the North Atlantic and Pacific oceans.



INCA TERN
Larosterna inca
F: Laridae
A distinctively patterned bird, the Inca tern is found in Peru and Chile, where it breeds on rocky coastlines.

BLACK TERN
Chlidonias niger
F: Laridae
This small freshwater tern breeds in the wetlands of the northern hemisphere and winters in S. America and Africa.

WHITE TERN
Gygis alba
F: Laridae
This small all-white tern from the islands of the tropical Atlantic and Indian oceans is notable for laying its eggs on bare branches in trees.

GREATER CRESTED TERN
Thalasseus bergii
F: Laridae
This Old World tern belongs to a group of related crested terns, characterized by a black nape tuft.

LESSER CRESTED TERN
Thalasseus bengalensis
F: Laridae
In this relative of the greater crested tern, the bill changes from yellow to orange during breeding.

LITTLE TERN
Sternula albifrons
F: Laridae
The Old World little tern belongs to a group of coastal species with a white "blaze" above the eye.

CASPIAN TERN
Hydroprogne caspia
F: Laridae
The largest tern species, this bird is found in most continents. It is a colonial ground-nester, like most sea terns.

SOOTY TERN
Onychoprion fuscatus
F: Laridae
This white-blazed sea tern breeds on tropical islands. It is also known as the wideawake tern because of its noisy colonies.

SAUNDERS'S TERN
Sternula saundersi
F: Laridae
A small tern from the Red Sea and Indian Ocean, Saunders's tern used to be considered a race of the little tern.

BRIDLED TERN
Onychoprion anaethetus
F: Laridae
This tern of tropical and subtropical regions has a white eye-blaze, similar to little and sooty terns. It spends much of its time at sea.

ROSEATE TERN
Sterna dougallii
F: Laridae
As with related sea terns, the roseate tern's black cap fades in winter. This bird is found mostly in the southern hemisphere and is migratory.

WHITE-CHEEKED TERN
Sterna repressa
F: Laridae
This species from the Red Sea and Indian Ocean can be identified by its plumage, which is darker than that of other grey terns.

BLACK-NAPED TERN
Sterna sumatrana
F: Laridae
Found on the Indian and Pacific oceans, the black-naped tern nests in small colonies, usually apart from other terns.

ARCTIC TERN
Sterna paradisaea
F: Laridae
This tern migrates the greatest distance of any animal: from its Arctic breeding grounds to Antarctica. It feeds on fish and crustaceans.

40–50 cm
16–20 in

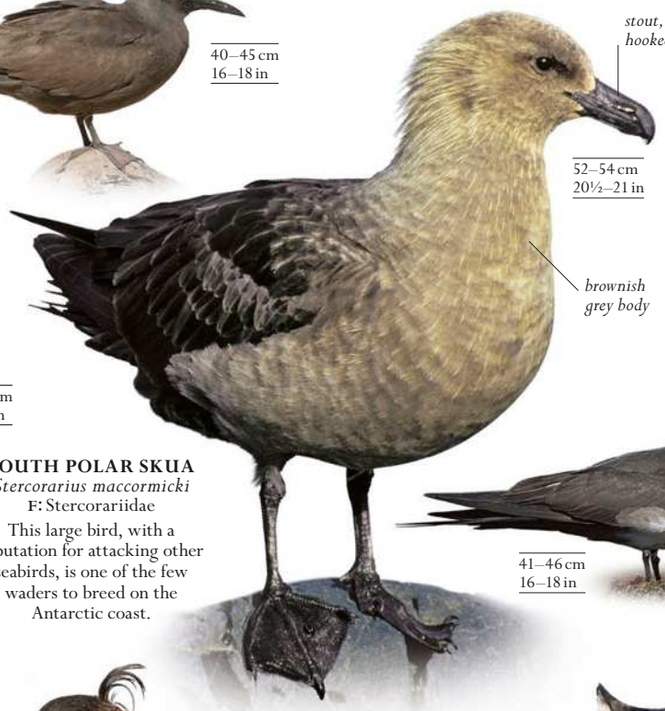
BLACK SKIMMER
Rynchops niger
F: Laridae

Skimmers are the only birds with projecting lower bill mandibles, used to skim water for fish. This species is found in N. and S. America.

40–45 cm
16–18 in

BROWN NODDY
Anous stolidus
F: Laridae

Noddies are dark or white tropical members of the tern family. The largest species, the brown noddy is widespread around the world.



stout, hooked bill

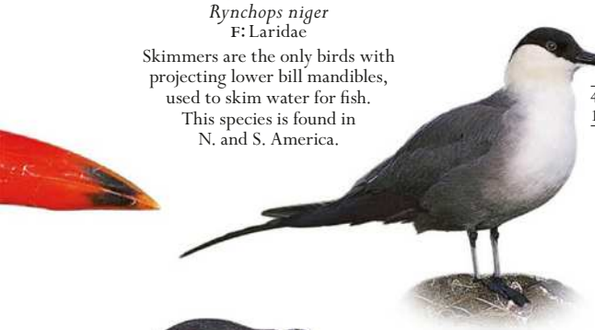
52–54 cm
20½–21 in

brownish grey body

46–51 cm
18–20 in

POMARINE JAEGER
Stercorarius pomarinus
F: Stercorariidae

Jaegers (also called skuas in Europe) are aggressive gull-like birds. This Arctic species will kill and eat other seabirds and even attack humans that threaten its nest.



48–53 cm
19–21 in

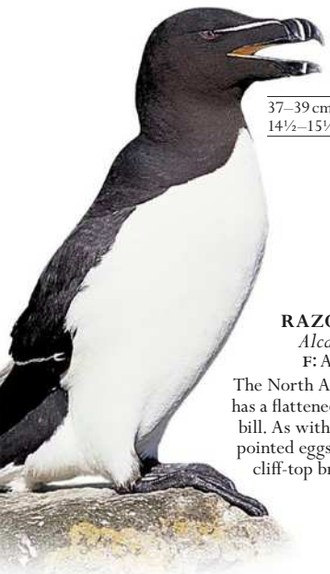
SOUTH POLAR SKUA
Stercorarius maccormicki
F: Stercorariidae

This large bird, with a reputation for attacking other seabirds, is one of the few waders to breed on the Antarctic coast.

41–46 cm
16–18 in

PARASITIC JAEGER
Stercorarius parasiticus
F: Stercorariidae

This is the commonest Arctic species of jaeger. Like most of its relatives, it mobs other seabirds to steal their prey.



37–39 cm
14½–15½ in

RAZORBILL
Alca torda
F: Alcidae

The North Atlantic razorbill has a flattened, white-barred bill. As with other auks, its pointed eggs cannot roll off cliff-top breeding sites.

LONG-TAILED JAEGER
Stercorarius longicaudus
F: Stercorariidae

Like other species, this smallest member of the jaeger family is migratory. It breeds in circumpolar regions and winters further south.

24–27 cm
9½–10½ in

CRESTED AUKLET
Aethia cristatella
F: Alcidae

Like other auklets, this North Pacific species feeds on planktonic crustaceans. Pairs anoint themselves with secretions from their backs during courtship.

24–25 cm
9½–10 in

MARBLED MURRELET
Brachyramphus marmoratus
F: Alcidae

This small American auk nests in trees in coniferous woods. Fledged chicks leave the nest at night and make for the sea.

17–19 cm
6½–7½ in

LITTLE AUK
Alle alle
F: Alcidae

This tiny auk breeds on Arctic islands and winters at sea further south. It feeds on tiny fish and crustaceans.

30–32 cm
12–12½ in

28–29 cm
11–11½ in

RHINOCEROS AUKLET
Cerorhinca monocerata
F: Alcidae

This North Pacific relative of puffins shares their burrow-nesting habits, and is named for the horn-like bill projection in breeding adults.

30–36 cm
12–14 in

white wing patch

red feet

PIGEON GUILLEMOT
Cepphus columba
F: Alcidae

This North Pacific auk, fully adapted to cold conditions, cannot migrate south through warmer waters, just as southern hemisphere penguins cannot move northwards.

BLACK GUILLEMOT
Cepphus grylle
F: Alcidae

This species of northern N. American and Eurasian coasts breeds in sparser colonies than other auks and winters mainly inshore.

dark brown to black head

38–41 cm
15–16 in

GUILLEMOT
Uria aalge
F: Alcidae

A typical diving member of the auk family, this bird breeds on North Atlantic and Pacific coasts, and winters at sea.

26–29 cm
10–11½ in

ATLANTIC PUFFIN
Fratercula arctica
F: Alcidae

A small, North Atlantic member of the auk family, this species– like other puffins – nests in colonies, in burrows, usually below turf.

34–36 cm
13½–14 in

TUFTED PUFFIN
Fratercula cirrhata
F: Alcidae

Like its Atlantic relative, this larger Pacific puffin catches small fish and can hold many at a time, crosswise, in its bill.

SANDGROUSE

Sand-coloured plumage camouflages these birds in their desert habitats, where they are well adapted for living in an extremely dry environment.

With their rounded body and short legs, sandgrouse might be mistaken for partridges until they take flight, darting quickly and acrobatically in the air. These birds, the Pterocliformes, are found in arid areas of Asia, Africa, Madagascar, and southern Europe. They are not related to the subarctic grouse species but are more closely related to pigeons.

Sandgrouse have long pointed wings and all species have cryptic plumage – mottled on the back, but often boldly marked with brown or white stripes or blotches on the head and underparts. They are sociable birds that gather in flocks to make early morning, or sometimes evening, forays to drinking holes, often travelling considerable distances. They feed exclusively on seeds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PTEROCLIFORMES
FAMILIES	1
SPECIES	16

WATER CARRIERS

Sandgrouse breed during the rainy season to take advantage of seed harvests. Their nest is nothing more than shallow depression on the ground. Both parents incubate and care for their young. Remarkably, the males supply water to their chicks, which are normally raised far from water sources. The male's belly feathers soak up and retain moisture when the bird visits a drinking hole. Back at the nest, the chicks drink from the parent's soaked feathers.

Namaqua sandgrouse drink at a watering hole. Like all sandgrouse, they gather in large flocks to confuse predators.

PALLAS'S SANDGROUSE
Syrrhaptes paradoxus
F: Pteroclidae
One of two C. Asian sandgrouse, this large species has feathered toes, a long tail, and a long flight feather on each wing.

30–41 cm
12–16 in

barred buff plumage

long, pointed tail

25–28 cm
10–11 in

black and white bands on forecrown (male only)

DOUBLE-BANDED SANDGROUSE
Pterocles bicinctus
F: Pteroclidae
A bird of southern African savanna and open woodland, this is one of several sandgrouse species in which the males have distinctive belly stripes.

CHESTNUT-BELLIED SANDGROUSE
Pterocles exustus
F: Pteroclidae
With a range that extends from Senegal to Kenya, and east as far as India, this bird of open desert gathers in huge flocks.

31–33 cm
12–13 in

white-barred wings

27–30 cm
10½–12 in

black breast band

24–26 cm
9½–10 in

CROWNED SANDGROUSE
Pterocles coronatus
F: Pteroclidae
This yellow-throated sandgrouse is found from the stony desert of the Sahara to Pakistan. It can tolerate high temperatures and even brackish water.

LICHTENSTEIN'S SANDGROUSE
Pterocles lichtensteinii
F: Pteroclidae
This small bird is less gregarious than other species of sandgrouse. It inhabits bushy scrubland, and semi-desert regions from N. and E. Africa to Pakistan.

PIGEONS AND DOVES

This is a highly successful group of seed-eating and fruit-eating birds that are distributed almost worldwide outside the coldest regions.

After the parrots, pigeons and doves form the largest group of vegetarian tree-perching birds: the order Columbiformes. But, whereas parrots have a heavy, hooked bill for cracking large nuts, pigeons have a less robust bill for feeding on smaller seeds and grain. Some tropical groups, such as the Indo-Pacific fruit doves, are specialized fruit-eaters of the rainforest canopy.

Most birds in this order are short-legged and a few spend almost all of their time on the ground. Pigeons and doves are unusual among birds in being able to suck up water when drinking without tilting back their head, owing to a pumping action in their food-pipe. This allows them to drink continuously, which is a particular benefit in arid environments. They can store food in their bill, and they feed their chicks on a secretion from the bill. This secretion is similar to mammalian milk.

THREATS AND EXTINCTIONS

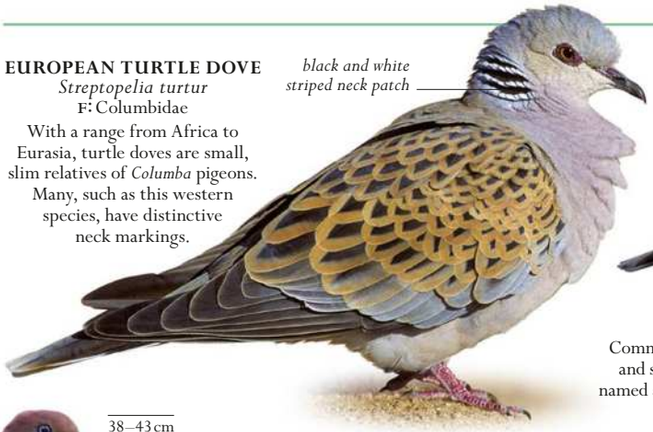
The success of many pigeon species is due to high rates of reproduction. However, some species are threatened by humans and others have already been lost. The 17th-century demise of the dodo, a vulnerable flightless species, was the result of human impact. And the passenger pigeon, once one of North America's commonest birds, was hunted to extinction in the 1900s.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	COLUMBIFORMES
FAMILIES	1
SPECIES	344

DEBATE

A MODIFIED PIGEON?

Mid-19th-century scientists placed the extinct flightless dodo from Mauritius in the pigeon order, and recent analysis indicates that it was related to the Nicobar pigeon. So the dodo was really a modified pigeon, with Indo-Pacific ancestors that might already have been flightless.



EUROPEAN TURTLE DOVE
Streptopelia turtur
F: Columbidae
With a range from Africa to Eurasia, turtle doves are small, slim relatives of *Columba* pigeons. Many, such as this western species, have distinctive neck markings.

black and white striped neck patch

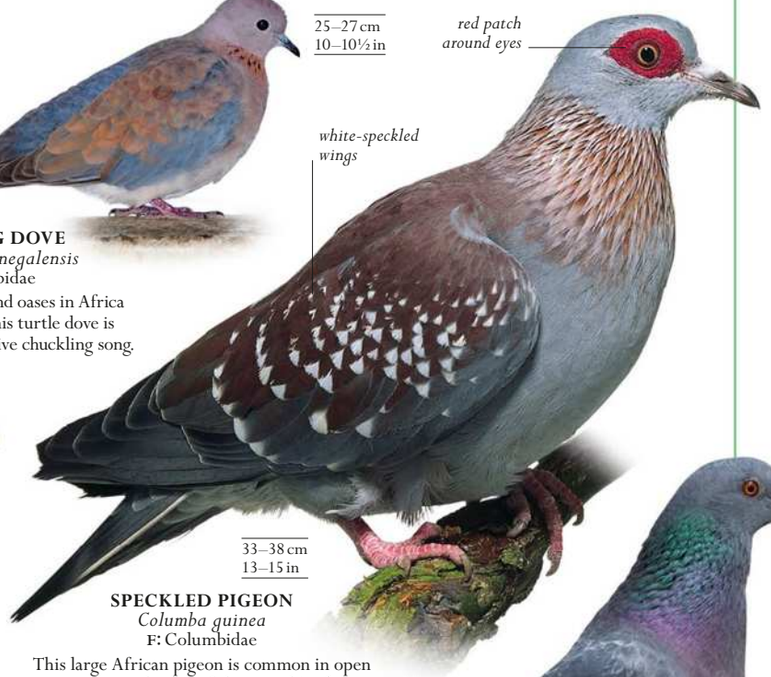
26–28 cm
10–11 in

25–27 cm
10–10½ in

LAUGHING DOVE
Streptopelia senegalensis
F: Columbidae
Common in villages and oases in Africa and southern Asia, this turtle dove is named after its distinctive chuckling song.

red patch around eyes

white-speckled wings



33–38 cm
13–15 in

SPECKLED PIGEON
Columba guinea
F: Columbidae
This large African pigeon is common in open country south of the Sahara, and it often gathers around towns and villages.

38–43 cm
15–17 in

BROWN CUCKOO-DOVE
Macropygia amboinensis
F: Columbidae
Long-tailed *Macropygia* doves are cuckoo-like birds of Indo-Pacific rainforests. Like others, this species from the Moluccas (Indonesia), New Guinea, and Australia has many races.

26–28 cm
10–11 in

NAMAQUA DOVE
Oena capensis
F: Columbidae
This long-tailed, ground-feeding species belongs to a group of small African wood doves. Its range extends into Madagascar and Saudi Arabia.

31–35 cm
12–14 in

DOMESTIC PIGEON
Columba livia
F: Columbidae
Domesticated and feral descendants of the rock pigeon are found in urban areas worldwide. These birds have variable plumage patterns.

32 cm
12½ in

PINK PIGEON
Nesoenas mayeri
F: Columbidae
Perhaps related to turtle doves, this rare bird is restricted to Mauritius. Its once threatened population recovered due to a successful captive-breeding programme.

38–43 cm
15–17 in

WOODPIGEON
Columba palumbus
F: Columbidae
This large W. Eurasian pigeon is commonly found in woods and farmland, and often enters parks and gardens.

31–35 cm
12–14 in

ROCK PIGEON
Columba livia
F: Columbidae
True wild pigeons inhabit cliffs and hedges. In its natural environment, this species lives in mountainous regions of Europe and Asia.

»

» PIGEONS AND DOVES

33–40 cm
13–16 in

NICOBAR PIGEON
Caloenas nicobarica
F: Columbidae

Possibly related to the extinct Mauritian dodo, this pigeon inhabits coastal regions and island forests from Malaysia to New Guinea.

17–23 cm
6½–9 in

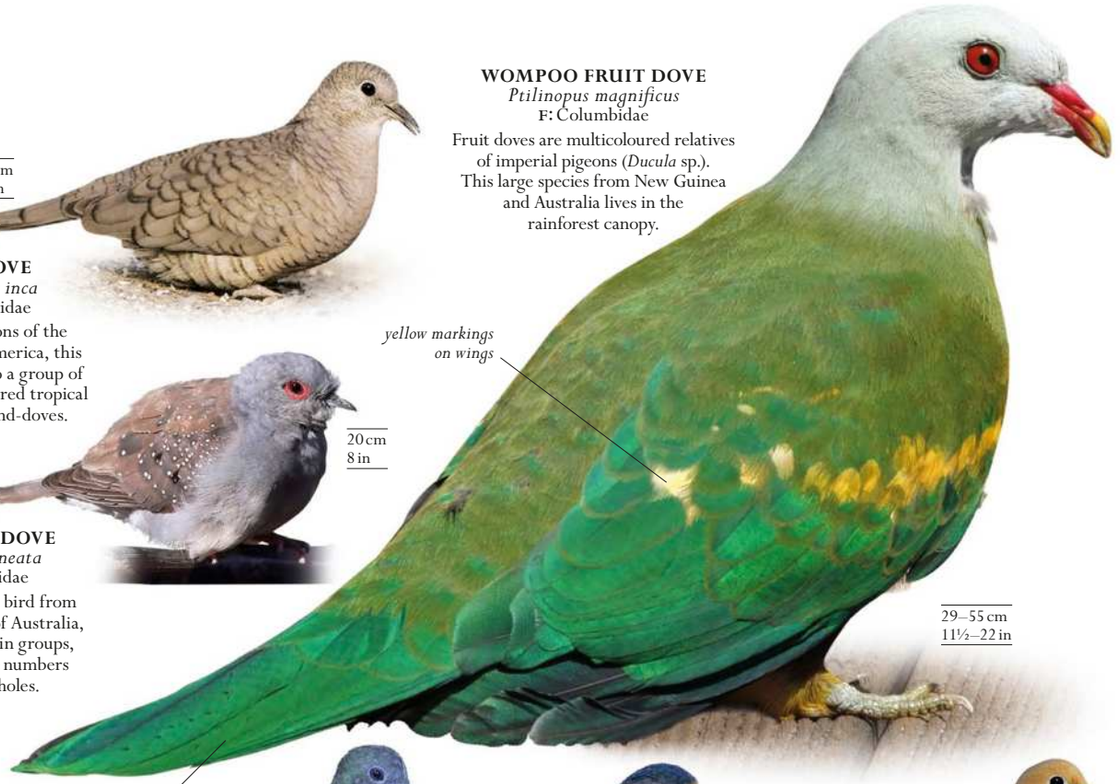
INCA DOVE
Columbina inca
F: Columbidae

From arid regions of the S. USA and C. America, this species belongs to a group of mostly drab-coloured tropical American ground-doves.

20 cm
8 in

DIAMOND DOVE
Geopelia cuneata
F: Columbidae

A small, nomadic bird from the dry interiors of Australia, this dove occurs in groups, flocking in large numbers at watering holes.



yellow markings on wings

WOMPOO FRUIT DOVE
Ptilinopus magnificus
F: Columbidae

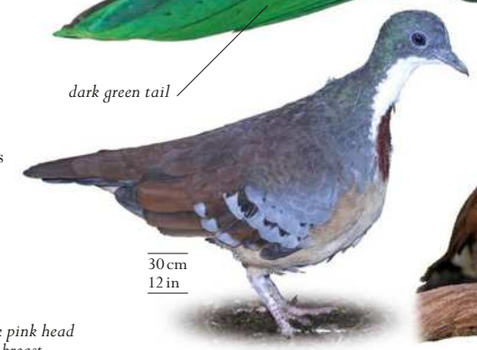
Fruit doves are multicoloured relatives of imperial pigeons (*Ducula* sp.). This large species from New Guinea and Australia lives in the rainforest canopy.

29–55 cm
11½–22 in

25–31 cm
10–12 in

WHITE-TIPPED DOVE
Leptotila verreauxi
F: Columbidae

A tropical relative of the mourning dove, this species is widespread in C. and S. America, and reaches as far north as Texas.



dark green tail

30 cm
12 in

MINDANAO BLEEDING-HEART PIGEON
Gallicolumba criniger
F: Columbidae

The five species of Philippine bleeding-heart pigeons are named for their blood-red breast patch. This bird inhabits the southern islands of the archipelago.

35 cm
14 in

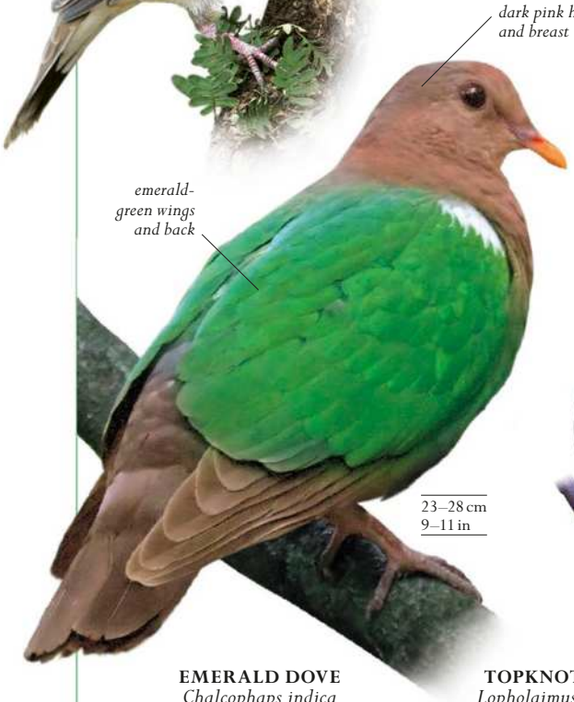
SULAWESI GROUND DOVE
Gallicolumba tristigmata
F: Columbidae

From the forests of Sulawesi, Indonesia, this terrestrial bird is related to Philippine bleeding-heart pigeons, and perhaps to various doves of arid Australia.

23–34 cm
9–13½ in

MOURNING DOVE
Zenaida macroura
F: Columbidae

So called because of its mournful call, this long-tailed dove occurs in open country throughout N. and C. America, and the Caribbean.



dark pink head and breast

emerald-green wings and back

23–28 cm
9–11 in

EMERALD DOVE
Chalcophaps indica
F: Columbidae

An iridescent green bird, this ground-feeding species occurs in rainforests from India to islands of the southwest Pacific. It has a diet of fruits and seeds.

40–46 cm
16–18 in

TOPKNOT PIGEON
Lopholaimus antarcticus
F:Columbidae

A large hawk-like pigeon from E. Australia, this species is named for the double crest of feathers on its forecrown and crown.

45 cm
18 in

GREEN IMPERIAL PIGEON
Ducula aenea
F: Columbidae

Found in rainforest canopy, from India to S.E. Asia, this large bird has a deep, booming call and has a diet consisting mainly of fruits.

39–44 cm
15½–17½ in

PIED IMPERIAL PIGEON
Ducula bicolor
F: Columbidae

Imperial pigeons are large, fruit-eating rainforest birds. This species from S.E. Asia and Australasia has a white plumage that is often stained due to its diet.

VICTORIA CROWNED PIGEON
Goura victoria
F: Columbidae

Crowned pigeons are the largest of the pigeons. This bird from N. New Guinea is distinguished from the southern crowned pigeon by its white-tipped crest.

SOUTHERN CROWNED PIGEON
Goura scheepmakeri
F: Columbidae

This species inhabits the forests of the southern part of New Guinea. It has bluish grey upperparts, a maroon chest, and a lacy crest.

WONGA PIGEON
Leucosarcia melanoleuca
F: Columbidae

Confined to eastern Australia, this distinctively patterned pigeon inhabits woodland and scrub from S. Queensland to Victoria.

PHEASANT PIGEON
Otidiphaps nobilis
F: Columbidae

Recent research suggests this New Guinean ground pigeon belongs to a group that includes crowned pigeons and perhaps even the extinct dodo.

KEY WEST QUAIL-DOVE
Geotrygon chrysia
F: Columbidae

Quail-doves are birds of tropical American forests. This iridescent species occurs in the Caribbean, including the Bahamas.

AFRICAN GREEN PIGEON
Treron calvus
F: Columbidae

More than 20 species of *Treron* pigeons occur in the tropical regions of Africa and Asia. This species is widespread south of the Sahara.

COMMON BRONZEWING
Phaps chalcoptera
F: Columbidae

Bronzewings are fast-flying Australian pigeons that feed on the ground. They have iridescent wing patches, which are particularly extensive in this widespread woodland species.

SPINIFEX PIGEON
Geophaps plumifera
F: Columbidae

This Australian bronzewing pigeon is found in arid, rocky habitats with an abundance of spinifex grass, in which it nests.

CRESTED PIGEON
Ocyphaps lophotes
F: Columbidae

One of several species of Australian bronzewing pigeons, this species is widespread in open country throughout the continent.

PARROTS AND COCKATOOS

Most parrots are birds of tropical forests, although a few favour open habitats. This order, the Psittaciformes, is diverse and often colourful.

The most recognizable feature of a parrot is its decurved bill. Both mandibles of the bill articulate with its skull: the upper mandible can move up, just as the lower can move down. This allows the bird not only to crack open hard seeds and nuts, but also to use its bill for gripping when clambering through trees. The legs are strong and the feet, with two forward-facing and two backward-facing toes, can grasp and manipulate foodstuffs. Bright colours are common, often in both sexes, with green plumage predominating. This colour is the result of feather structure, which scatters light on yellow pigment. The Australasian cockatoos – parrots with a distinctive erectile crest – lack this feather texture and so lack green and blue colours.

Australasia's high parrot diversity, which includes the brush-tongued, nectar-feeding lorikeets, suggests that the group originated in this part of the world. The most primitive parrots, the kea and the nocturnal, flightless kakapo, are both found in New Zealand.

SOCIAL SPECIES

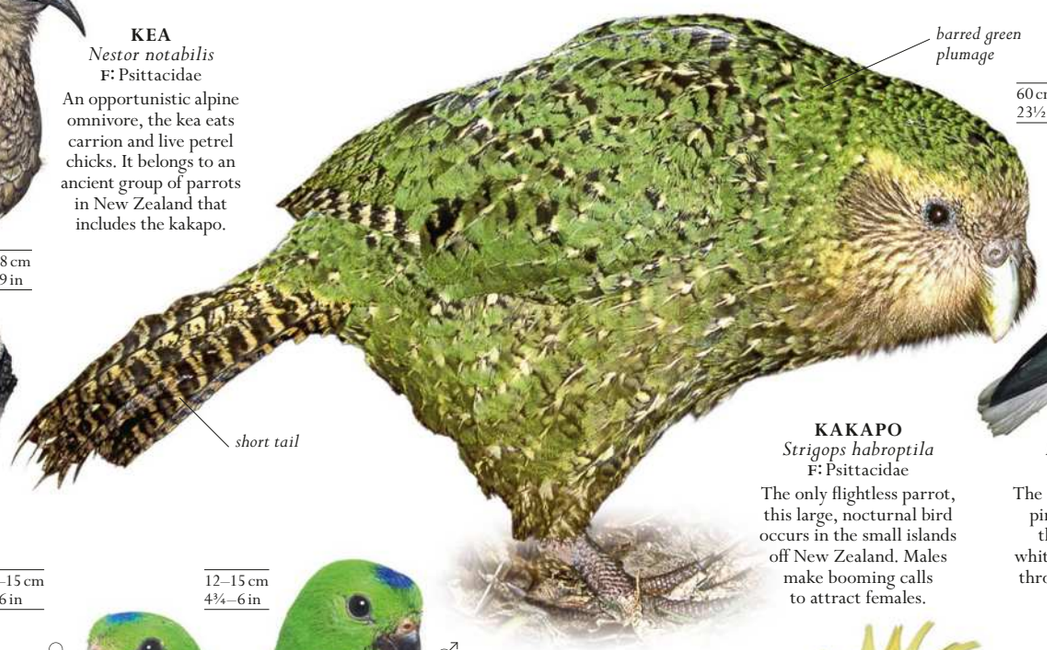
Parrots are sociable, often living in large flocks, and almost all species form strong pair bonds. Their engaging personalities make them popular as pets, but the international cagebird trade has driven many species to the edge of extinction.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PSITTACIFORMES
FAMILIES	4
SPECIES	398

Green-winged macaws socialize at a clay-lick, which provides sodium in an area where the mineral is very limited.

KEA
Nestor notabilis
F: Psittacidae
An opportunistic alpine omnivore, the kea eats carrion and live petrel chicks. It belongs to an ancient group of parrots in New Zealand that includes the kakapo.

48 cm
19 in



60 cm
23½ in

36 cm
14 in

KAKAPO
Strigops habroptila
F: Psittacidae
The only flightless parrot, this large, nocturnal bird occurs in the small islands off New Zealand. Males make booming calls to attract females.

GALAH
Eolophus roseicapilla
F: Psittacidae
The only cockatoo with a deep pink neck and underparts, this small relative of the white cockatoos is widespread throughout Australia in areas with scattered trees.

13–15 cm
5–6 in

VERNAL HANGING PARROT
Loriculus vernalis
F: Psittacidae
Hanging parrots are Indo-Pacific birds, even though recent genetic evidence suggests affinities with African lovebirds. This species is found from India to Thailand.

12–15 cm
4¾–6 in

♀ ♂

BLUE-CROWNED HANGING PARROT
Loriculus galgulus
F: Psittacidae
Hanging parrots, unusually among birds, sleep upside down. Like other such parrots, this small forest bird from S.E. Asia has a short tail and mainly green plumage.

49 cm
19½ in

SULPHUR-CRESTED COCKATOO
Cacatua galerita
F: Psittacidae
White cockatoos are screeching parrots with a range that extends from Indonesia to the Pacific Rim. This species occurs in New Guinea and Australia.

50–61 cm
20–24 in

RED-TAILED BLACK COCKATOO
Calyptorhynchus banksii
F: Psittacidae
One of several Australian black cockatoos with coloured tail panels, this glossy species has a typical wailing call and ponderous wing beats.

32 cm
12½ in

COCKATIEL
Nymphicus hollandicus
F: Psittacidae

A bird of Australia's dry interior, this species resembles a parakeet, but its DNA shows it is a miniature cockatoo.

30 cm
12 in

CHATTERING LORY
Lorius garrulus
F: Psittacidae

One of a group of green-winged red lories from New Guinea and surrounding islands, this species is from the Moluccas.

25 cm
10 in

DUSKY LORY
Pseudeos fuscata
F: Psittacidae

The patchy brown coloration of this species is unique among lories. This bird occurs in New Guinea and nearby islands.

30 cm
12 in

BLACK-WINGED LORY
Eos cyanogenia
F: Psittacidae

The *Eos* lories are vividly red and violet Indonesian birds. This is the easternmost species, restricted to the area around Geelvink Bay, New Guinea.

24 cm
9½ in

OLIVE-HEADED LORIKEET
Trichoglossus euteles
F: Psittacidae

Found on the island of Timor, this long-tailed relative of the rainbow lorikeet has bright green plumage, typical of many parrots.

18 cm
7 in

VARIED LORIKEET
Psitteuteles versicolor
F: Psittacidae

A small lorikeet from northern Australian woodlands, this species nests in eucalyptus tree cavities, like many other parrots in its habitat.

43 cm
17 in

25–30 cm
10–12 in

RAINBOW LORIKEET
Trichoglossus haematodus
F: Psittacidae

A variable species, this bird is found in many habitats with nectar-giving blossom. Its range includes most of Australasia and the islands of the southwest Pacific.

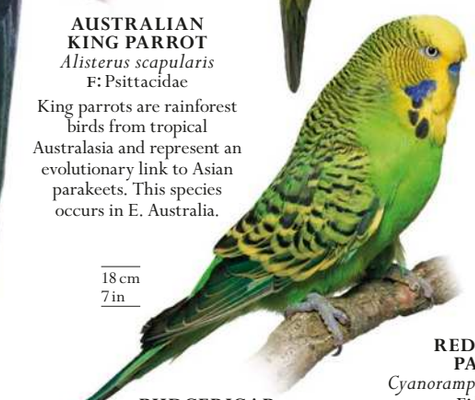
33–39 cm
13–15½ in

ECLECTUS PARROT
Eclectus roratus
F: Psittacidae

Males and females of this parrot are so different they were originally classified as separate species. They are found in tropical Australasian rainforests.

AUSTRALIAN KING PARROT
Alisterus scapularis
F: Psittacidae

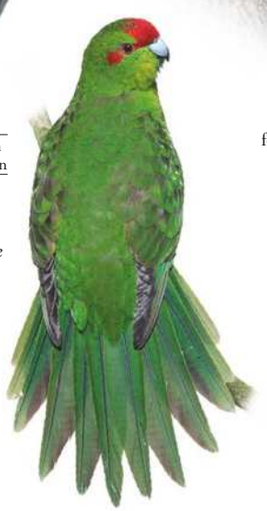
King parrots are rainforest birds from tropical Australasia and represent an evolutionary link to Asian parakeets. This species occurs in E. Australia.



18 cm
7 in

BUDGERIGAR
Melopsittacus undulatus
F: Psittacidae

A nomadic Australian bird, this small parrot from arid regions flocks to watering holes. Despite being a seed-eater, it is related to nectar-feeding lorikeets.



27 cm
10½ in

RED-FRONTED PARAKEET
Cyanoramphus novaezelandiae
F: Psittacidae

Small parakeets with coloured foreheads have diversified in the southwest Pacific, and include the only parakeets – like this species – from New Zealand.

34–38 cm
13½–15 in

AUSTRALIAN RINGNECK
Barnardius zonarius
F: Psittacidae

Named for its yellow neck-ring, this Australian bird has black- and green-headed forms. It is widespread in woodland.

»

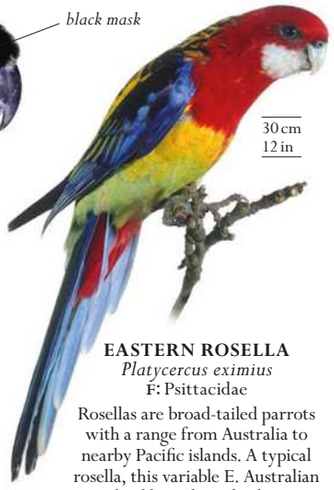
» PARROTS AND COCKATOOS

RED-FAN PARROT
Deroptyus accipitrinus
F: Psittacidae

Possibly related more closely to macaws than to other short-tailed parrots, this S. American parrot raises a red neck ruff when excited.

TURQUOISE PARROT
Neophema pulchella
F: Psittacidae

A member of a group of small, green grass parrots from Australia, the turquoise parrot is an open woodland bird from the southeast of the continent.



EASTERN ROSELLA
Platycercus eximius
F: Psittacidae

Rosellas are broad-tailed parrots with a range from Australia to nearby Pacific islands. A typical rosella, this variable E. Australian bird has white cheeks.

ROSE-RINGED PARAKEET
Psittacula krameri
F: Psittacidae

This is the most widespread Asian parakeet that reaches westwards into N. Africa. This species has also been introduced in Europe.

MASKED SHINING PARROT
Prosopeia personata
F: Psittacidae

One of the three species of shining parrots restricted to Fiji, this parrot is declining in numbers due to loss of its native forest.

PRINCESS PARROT
Polytelis alexandrae
F: Psittacidae

A nomad from central Australia, this bird follows watercourses and gathers near spinifex grass. It often breeds in small colonies in eucalyptus trees.

SUPERB PARROT
Polytelis swainsonii
F: Psittacidae

This S.E. Australian bird belongs to a group of long-tailed Australian parrots and breeds in red gum forests. It is rapidly declining in number.

GREY PARROT
Psittacus erithacus
F: Psittacidae

A native of African rainforests, this highly intelligent species is an accomplished mimic. This has led to its exploitation in the bird trade.

YELLOW-COLLARED LOVEBIRD
Agapornis personatus
F: Psittacidae

Lovebirds are small African parrots that live in small flocks. Unlike most parrots, this Tanzanian species builds a nest – a domed structure in a tree cavity.

ROSY-FACED LOVEBIRD
Agapornis roseicollis
F: Psittacidae

This social lovebird from dry woodland and semi-desert habitats of S.W. Africa habitually gathers near watering holes.

BROWN-NECKED PARROT
Poicephalus robustus
F: Psittacidae

The largest of a group of mainly green-grey parrots from Africa, this bird occurs in forests from Gambia to the Cape of Good Hope.

85 cm
34 in

BLUE-AND-YELLOW MACAW
Ara ararauna
F: Psittacidae

Macaws are large, long-tailed parrots with sparsely feathered facial patches. One of two blue and yellow species, this bird comes from northern S. America.

55–60 cm
22–23½ in

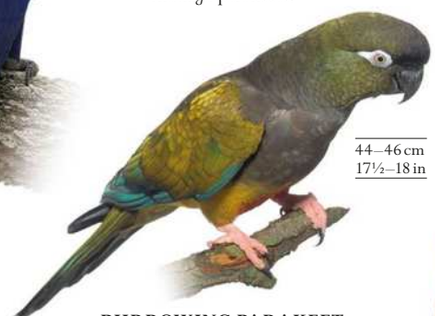
RED-FRONTED MACAW
Ara rubrogenys
F: Psittacidae

This small macaw is restricted to the arid scrub of central Bolivia. Its small population is threatened by habitat loss and wildlife trafficking.

1 m
3¼ ft

HYACINTH MACAW
Anodorhynchus hyacinthinus
F: Psittacidae

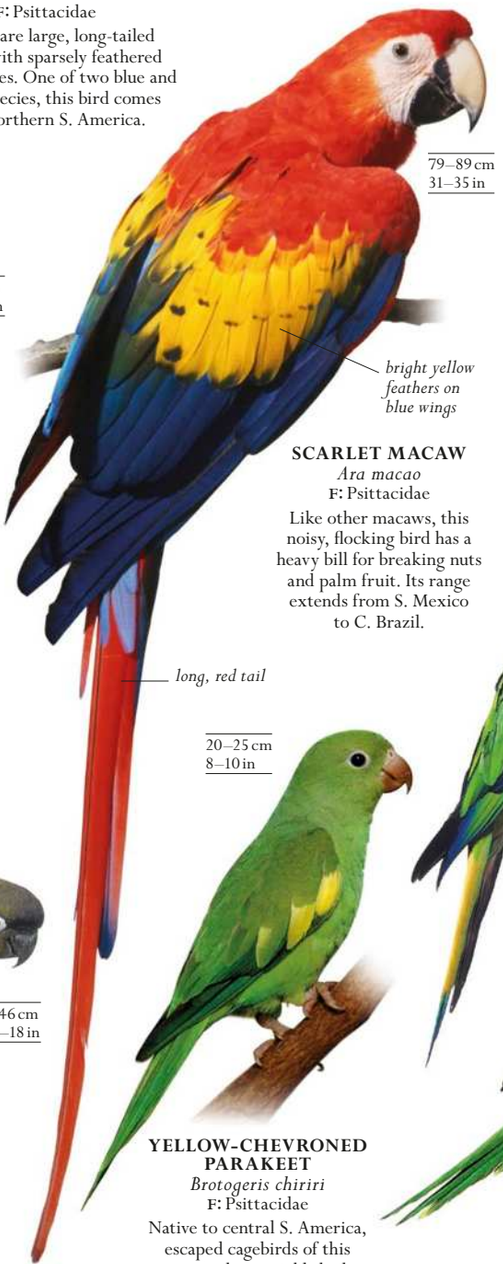
Unlike other macaws, this giant Brazilian parrot has its facial patch reduced to an eye-ring – similar to that of the related *Aratinga* parakeets.



44–46 cm
17½–18 in

BURROWING PARAKEET
Cyanoliseus patagonus
F: Psittacidae

A Patagonian relative of macaws, this colonial breeder nests in tunnels in earth banks. It forms faithful pair bonds, unlike most birds.



79–89 cm
31–35 in

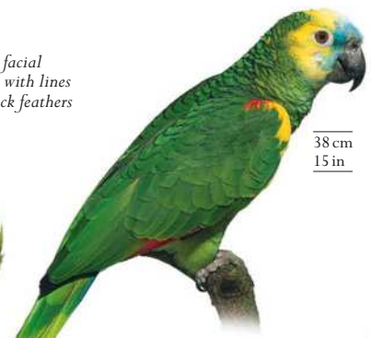
SCARLET MACAW
Ara macao
F: Psittacidae

Like other macaws, this noisy, flocking bird has a heavy bill for breaking nuts and palm fruit. Its range extends from S. Mexico to C. Brazil.

20–25 cm
8–10 in

YELLOW-CHEVRONED PARAKEET
Brotogeris chiriri
F: Psittacidae

Native to central S. America, escaped cagebirds of this species have established feral populations in warmer parts of the USA.



38 cm
15 in

BLUE-FRONTED PARROT
Amazona aestiva
F: Psittacidae

A member of a large group of mostly green parrots, this species occurs in open forest habitats of central-eastern S. America.

40 cm
16 in

ST VINCENT PARROT
Amazona guildingii
F: Psittacidae

Several Caribbean *Amazona* parrots are faced with extinction. This large species is being conserved by an ongoing breeding programme in its native island of St Vincent.

24–28 cm
9½–11 in

BLUE-HEADED PARROT
Pionus menstruus
F: Psittacidae

A relative of the *Amazona* parrots, this small parrot is common in lowland forests from Costa Rica to Bolivia.

12–14 cm
4¾–5½ in

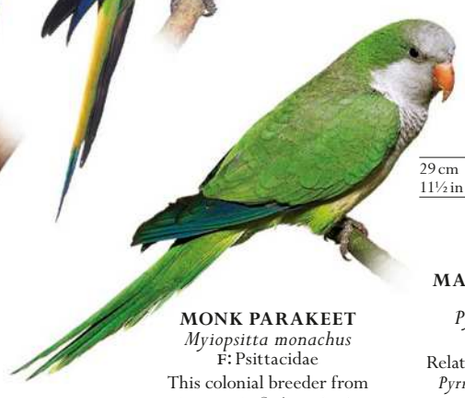
PACIFIC PARROTLET
Forpus coelestis
F: Psittacidae

Parrotlets are tiny green American parrots; only New Guinean pygmy parrots are smaller. This species occurs in western Ecuador and Peru.

30 cm
12 in

JANDAYA PARAKEET
Aratinga jandaya
F: Psittacidae

Aratinga is a genus of predominantly green "mini-macaws" found in northeastern Brazil. Some have extensive splashes of golden coloration.



29 cm
11½ in

MONK PARAKEET
Myiopsitta monachus
F: Psittacidae

This colonial breeder from temperate S. America is the only parrot to build a stick nest, often a large communal structure.

25 cm
10 in

MAROON-BELLIED PARAKEET
Pyrrhura frontalis
F: Psittacidae

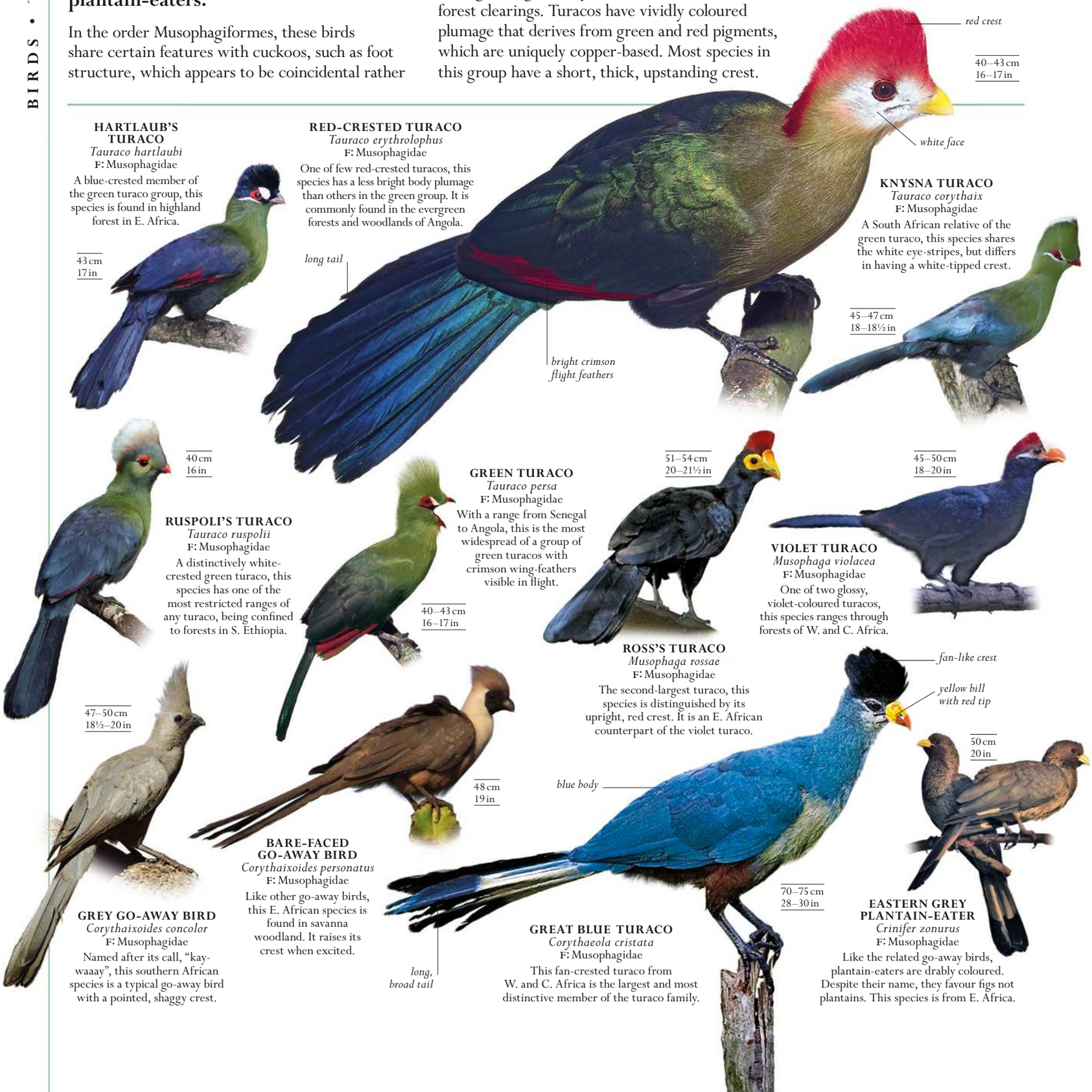
Relatives of *Aratinga*, most *Pyrrhura* parakeets have prominent splashes of maroon or red, such as this species from eastern S. America.

TURACOS

Confined to Africa, this group includes the strikingly colourful turacos, which are largely green, blue or purple, the dull, greyish go-away birds (named for their distinctive nasal calls), and the plantain-eaters.

In the order Musophagiformes, these birds share certain features with cuckoos, such as foot structure, which appears to be coincidental rather than indicative of any relationship. They live in forests, subsisting largely on seasonal fruit. Although their bill is remarkably short, a long tail helps them maintain balance when reaching for food in the tree canopy. They move heavily through foliage and fly short distances across forest clearings. Turacos have vividly coloured plumage that derives from green and red pigments, which are uniquely copper-based. Most species in this group have a short, thick, upstanding crest.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	MUSOPHAGIFORMES
FAMILIES	1
SPECIES	23



HARTLAUB'S TURACO
Tauraco hartlaubi
F: Musophagidae
A blue-crested member of the green turaco group, this species is found in highland forest in E. Africa.

RED-CRESTED TURACO
Tauraco erythrolophus
F: Musophagidae
One of few red-crested turacos, this species has a less bright body plumage than others in the green group. It is commonly found in the evergreen forests and woodlands of Angola.

KNYSNA TURACO
Tauraco corythaix
F: Musophagidae
A South African relative of the green turaco, this species shares the white eye-stripes, but differs in having a white-tipped crest.

RUSPOLI'S TURACO
Tauraco ruspolii
F: Musophagidae
A distinctively white-crested green turaco, this species has one of the most restricted ranges of any turaco, being confined to forests in S. Ethiopia.

GREEN TURACO
Tauraco persa
F: Musophagidae
With a range from Senegal to Angola, this is the most widespread of a group of green turacos with crimson wing-feathers visible in flight.

VIOLET TURACO
Musophaga violacea
F: Musophagidae
One of two glossy, violet-coloured turacos, this species ranges through forests of W. and C. Africa.

ROSS'S TURACO
Musophaga rossae
F: Musophagidae
The second-largest turaco, this species is distinguished by its upright, red crest. It is an E. African counterpart of the violet turaco.

BARE-FACED GO-AWAY BIRD
Corythaixoides personatus
F: Musophagidae
Like other go-away birds, this E. African species is found in savanna woodland. It raises its crest when excited.

GREY GO-AWAY BIRD
Corythaixoides concolor
F: Musophagidae
Named after its call, "kay-waaay", this southern African species is a typical go-away bird with a pointed, shaggy crest.

GREAT BLUE TURACO
Corythaeola cristata
F: Musophagidae
This fan-crested turaco from W. and C. Africa is the largest and most distinctive member of the turaco family.

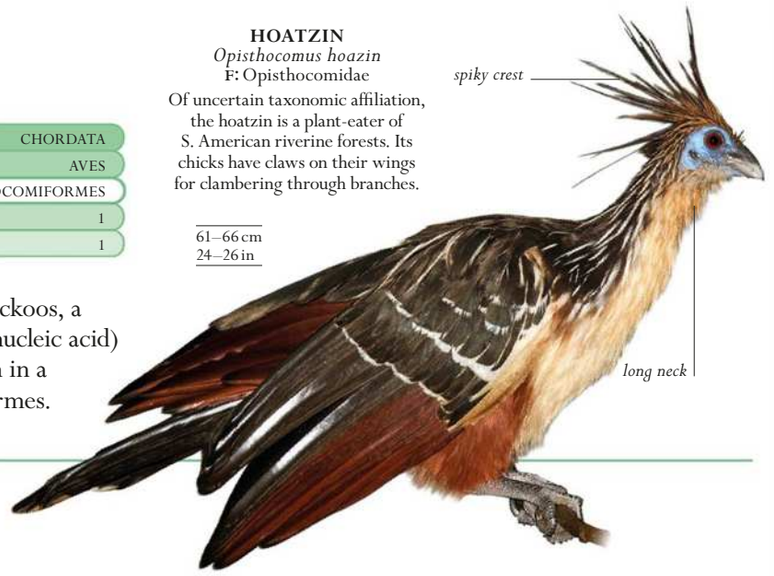
EASTERN GREY PLANTAIN-EATER
Crinifer zonurus
F: Musophagidae
Like the related go-away birds, plantain-eaters are drably coloured. Despite their name, they favour figs not plantains. This species is from E. Africa.

HOATZIN

The hoatzin is an enigmatic South American bird that has an entirely vegetarian diet of leaves.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	OPISTHOCOMIFORMES
FAMILIES	1
SPECIES	1

Some features of the hoatzin, such as strong feet and a short, curved bill, are similar to those of gamebirds. However, the hoatzin also shares features with cuckoos, a relationship that appeared to be confirmed by early DNA (deoxyribonucleic acid) studies. Later research has thrown doubt on this – leaving the hoatzin in a group of its own, the only representative of the order Opisthocomiformes.



HOATZIN
Opisthocomus hoazin
F: Opisthocomidae
Of uncertain taxonomic affiliation, the hoatzin is a plant-eater of S. American riverine forests. Its chicks have claws on their wings for clambering through branches.

61–66 cm
24–26 in

CUCKOOS

Cuckoos are rather short-legged, long-winged, mostly softly feathered birds that include dull, greyish species as well as a small group with patches of vivid emerald green.

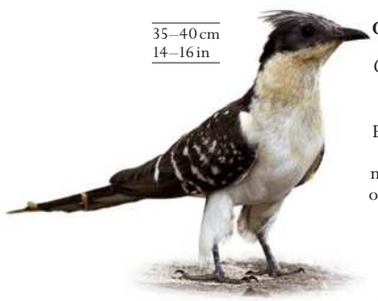
All members of the Cuculiformes have feet with two toes pointing forwards and two backwards. The most primitive cuckoos are heavy-bodied American birds that forage on or near the ground – a lifestyle taken to the extreme by the sprinting roadrunner. Inspite of their reputation, not all cuckoos lay their eggs in other birds' nests.

Almost all these ground cuckoos build nests and raise their own young, as do their Old World counterparts, such as the tropical coucals and couas. Cuckoos that lay eggs in nests of other bird species are called "brood parasites". Remarkably, this habit has evolved independently at least twice in Old World cuckoos. The chicks of crested cuckoos (*Clamator* sp.) outgrow their host nest so quickly that host chicks die from starvation. Another line of cuckoos, which includes the Eurasian common cuckoo, evolved chicks with more murderous intent: they actively eject host eggs and chicks.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CUCULIFORMES
FAMILIES	1
SPECIES	149

28–34 cm
11–13½ in

HIMALAYAN CUCKOO
Cuculus saturatus
F: Cuculidae
This species from Asia and Australia is typical of a group of Old World barred cuckoos that resemble sparrowhawks – a fact that perhaps helps them to flush hosts from nests.



35–40 cm
14–16 in

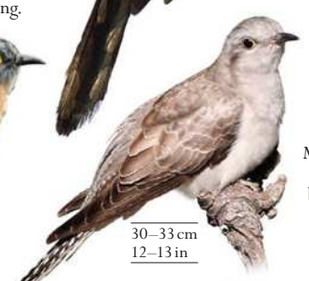
GREAT SPOTTED CUCKOO
Clamator glandarius
F: Cuculidae
With a range from Europe to Africa, this cuckoo lays eggs in magpie nests, but, like other *Clamator* species, does not evict the host's young.

34 cm
13½ in

JACOBIN CUCKOO
Clamator jacobinus
F: Cuculidae
Clamator cuckoos are large crested Old World cuckoos. Like others, this tropical species from Africa and Asia eats hairy caterpillars that are avoided by competitors.

32–34 cm
12–13½ in

COMMON CUCKOO
Cuculus canorus
F: Cuculidae
This widespread Eurasian species overwinters in Africa and S. Asia. It has the well-known "cooc-coo" call that gives cuckoos their name.



30–33 cm
12–13 in

PALLID CUCKOO
Cacomantis pallidus
F: Cuculidae
Many Old World cuckoos have barred plumage, but in some, such as this Australian species, the barring occurs only in immature birds.

24 cm
9½ in

FAN-TAILED CUCKOO
Cacomantis flabelliformis
F: Cuculidae
This brown-breasted cuckoo of Australasian woodlands is one of very few cuckoos that are found in the Pacific – and the only one in Fiji.

24–28 cm
9½–11 in

GREY-BELLIED CUCKOO
Cacomantis passerinus
F: Cuculidae
Found from the Malay Peninsula to Australia, this bird is one of many Indo-Pacific, brown-breasted species that are closely related to *Cuculus* cuckoos.

23 cm
9 in

BRUSH CUCKOO
Cacomantis variolosus
F: Cuculidae
Related to Asian brown-breasted cuckoos, this plain-coloured species breeds in southern Asia. The montane populations migrate to warm lowlands in winter.

17–19 cm
6½–7½ in

DIDERIC CUCKOO
Chrysococcyx caprius
F: Cuculidae
An African member of a group of small bronze-sheened tropical cuckoos, this species lays its eggs in the nest of the weever bird.

16–18 cm
6½–7 in

KLAAS'S CUCKOO
Chrysococcyx klaas
F: Cuculidae
This small African cuckoo is a close relative of the dideric cuckoo, differing in being greener and lacking white wing spots.

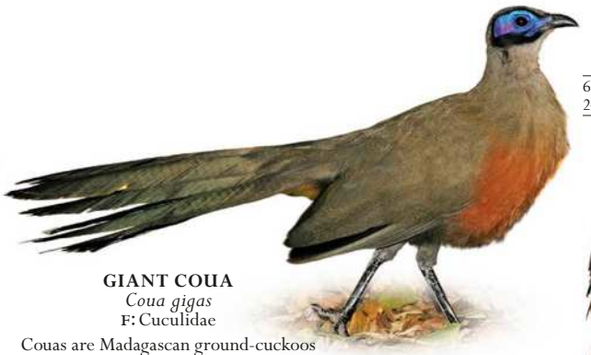
» CUCKOOS

YELLOW-BILLED CUCKOO
Coccyzus americanus
F: Cuculidae

One of several American tree cuckoos with brown plumage and white-spotted tails, this species migrates between N. and S. America.

BLACK-BELLIED CUCKOO
Piaya melanogaster
F: Cuculidae

Like other American tree cuckoos, this species builds its own nest and cares for its young. It is found from Colombia to Bolivia.



GIANT COUA
Coua gigas
F: Cuculidae

Couas are Madagascan ground-cuckoos with blue facial skin and long eyelashes. This bird lives in dry coastal forests.

GUIRA CUCKOO
Guira guira
F: Cuculidae

This shaggy-looking bird belongs to the ani group of S. American cuckoos. It occurs in noisy flocks and nests communally in trees.

GREATER COUCAL
Centropus sinensis
F: Cuculidae

Like other coucals, this S. Asian species is a strong-legged bird with spurred feet and long hind claws.

PAVONINE CUCKOO
Dromococcyx pavoninus
F: Cuculidae

A smaller relative of the pheasant-cuckoo, this tropical S. American bird is a ground predator. It feeds on invertebrates.

PHEASANT-CUCKOO
Dromococcyx phasianellus
F: Cuculidae

This American ground cuckoo inhabits the forest floor in tropical S. America, where it lays its eggs in the nests of smaller passerines.

PHEASANT-COUCAL
Centropus phasianinus
F: Cuculidae

Parental care in coucals is provided mostly by the males. This Australasian species has a black body when breeding, and builds a cup-shaped nest in grass.

GROOVE-BILLED ANI
Crotophaga sulcirostris
F: Cuculidae

A heavy-billed American cuckoo occurring from California to Argentina, the communal-nesting ani is a clumsy flier but runs well.

CORAL-BILLED GROUND CUCKOO
Carpococcyx renauldi
F: Cuculidae

One of three species of Asian ground cuckoos related to Madagascan couas, this bird inhabits rainforests of S.E. Asia.

GREATER ROADRUNNER
Geococcyx californianus
F: Cuculidae

This fast-running predator is an American ground cuckoo. The roadrunner inhabits deserts and nests in cacti. and occurs in a range from the USA to Mexico.

COMMON KOEL
Eudynamys scolopaceus
F: Cuculidae

Unusually for cuckoos, this tropical brood parasite, found from Asia to Australasia, is a fruit-eater. Males are black and females are grey-brown.

OWLS

With acute senses, powerful weaponry, and noiseless flight, owls are superbly adapted as night-time hunters. Only a few species are active by day.

Although not related to birds of prey, owls, which belong to the order Strigiformes, are similarly equipped with a hooked bill and strong talons. Most species have cryptic plumage for camouflage when roosting during the day. Barn owls are distinct in having a heart-shaped facial disc; owls with a round facial disc are more typical, although they are a family of great diversity, ranging from hawk-like owlets to massive eagle owls.

SIGHT AND HEARING

All owls have large, forward-facing eyes that are efficient at letting in light and allow the birds to see well in dim conditions. Their binocular vision is good for judging distance during attacks, but the eyes are fixed in their sockets. To track moving prey, an owl must turn its whole head. The bird can do this through a wide range of movement by means of a long flexible neck concealed beneath the plumage. Owls also have highly sensitive hearing, helped by the facial disc, which serves to guide sounds to the large ear openings. A downward-pointing bill minimizes interference with sound. An owl can determine the direction of prey with great accuracy from sounds. Most of the nocturnal species have one ear slightly higher than the other, an arrangement that helps them to pick up sounds in a vertical direction, too.

SILENT HUNTERS

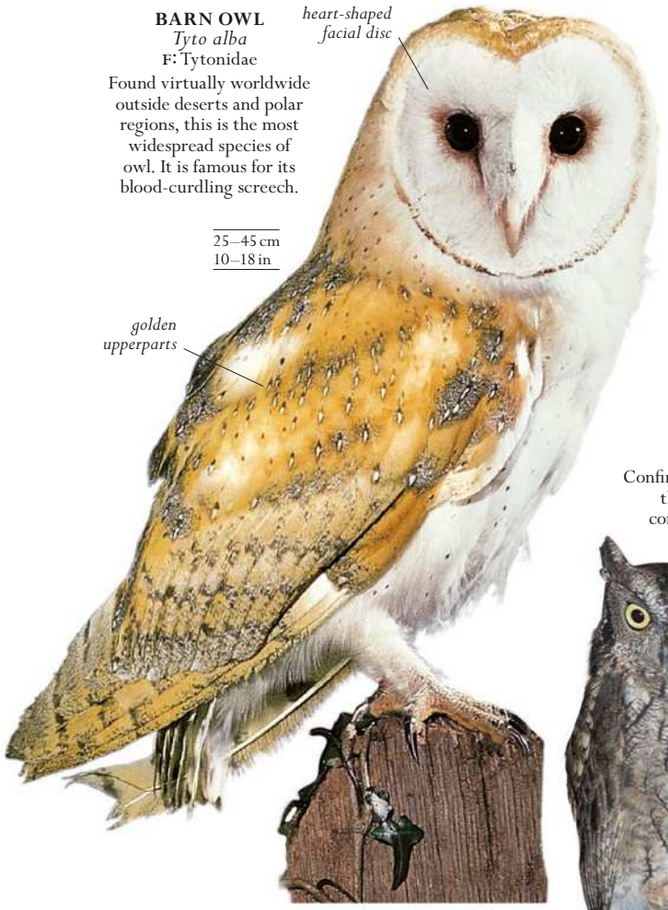
Hunting owls usually swoop on their prey and extend their feet to make the grab. The approach is almost silent on large rounded wings that require minimal flapping. A soft fringe of serrated flight feathers breaks up air turbulence, muffling the sound of wing-beats. Some day-flying species lack these fringed feathers. Most owls prey on small mammals such as mice and voles, but some of the smaller species take large insects, and a few owls are specialized fish-eaters. An owl tears larger carcasses apart with its hooked bill, but swallows smaller prey whole. The indigestible parts of a meal, such as bones and fur, are compressed in part of the stomach and later regurgitated in the form of a pellet.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	STRIGIFORMES
FAMILIES	2
SPECIES	243

DEBATE

SCREECH OWLS

There are over 60 species of owls in the genus *Otus*. In their native forests, these small, cryptically patterned birds are most reliably identified by their call. Although individual species' calls differ in frequency and duration of notes, *Otus* owls fall into two well-defined groups: scops owls, from the Old World, which call with slow notes; and American screech owls, which have faster, piercing trills. The distinction was enough for some ornithologists to advocate placing the screech owls in their own separate genus – *Megascops*. Recent research shows that this division is underpinned by differences in DNA.



BARN OWL
Tyto alba
F: Tytonidae
Found virtually worldwide outside deserts and polar regions, this is the most widespread species of owl. It is famous for its blood-curdling screech.
25–45 cm
10–18 in

26–43 cm
10–17 in

ASHY-FACED OWL
Tyto glaucops
F: Tytonidae
Confined to the Caribbean island of Hispaniola, this owl of dry forest is threatened by competition from the stronger barn owl.

19–20 cm
7½–8 in

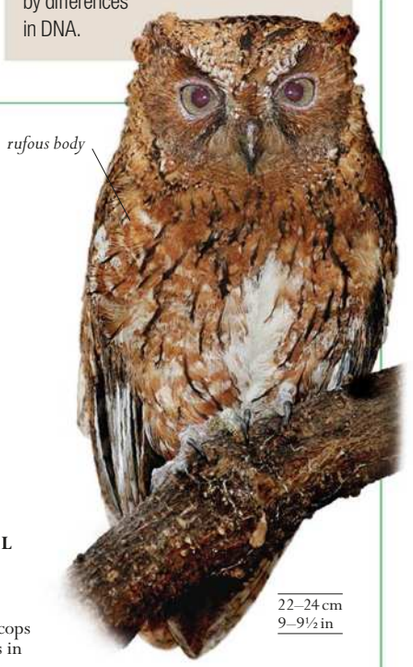
EURASIAN SCOPS OWL
Otus scops
F: Strigidae
This small, agile owl from W. Eurasia is a typical tufted scops owl of the Old World. It nests in cavities of trees or buildings.

19–25 cm
7½–10 in

WESTERN SCREECH OWL
Megascops kennicottii
F: Strigidae
A common owl of western N. America, this species favours wooded areas near rivers but will also enter parkland and towns.

16–25 cm
6½–10 in

EASTERN SCREECH OWL
Megascops asio
F: Strigidae
Widespread throughout eastern N. America, this owl occurs in grey or rufous (reddish brown) colour varieties, with more rufous birds further east in its range.



22–24 cm
9–9½ in

RAINFOREST SCOPS OWL
Otus rutilus
F: Strigidae
Restricted to Madagascar, this owl is common in wooded areas. Most are grey; the rarer reddish brown birds are confined to rainforests.

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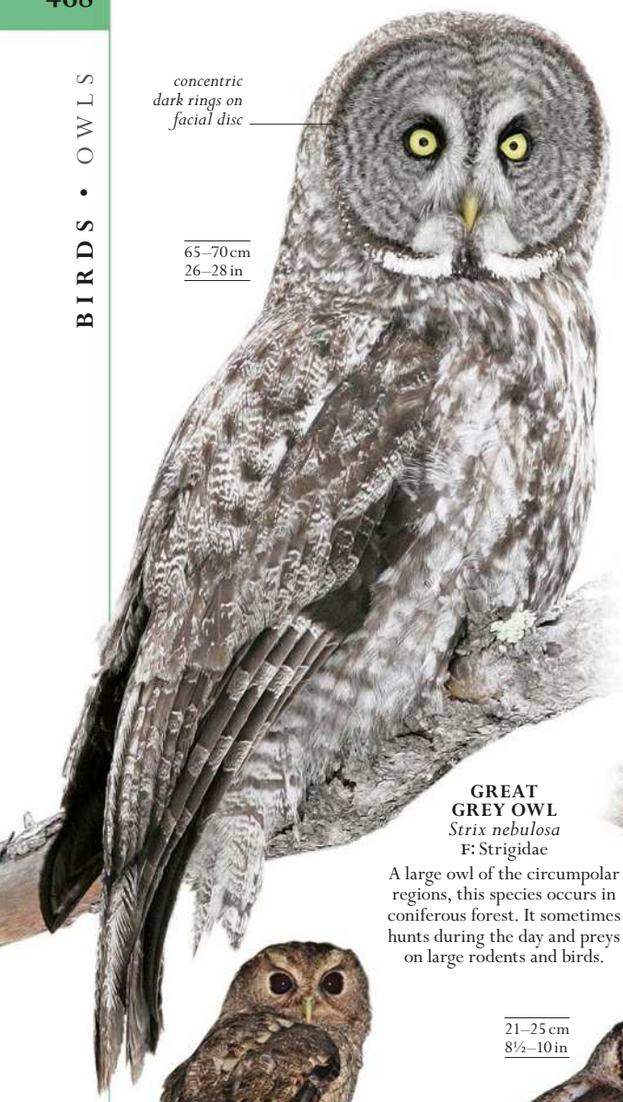


GREAT GREY OWL
Strix nebulosa
F: Strigidae

A large owl of the circumpolar regions, this species occurs in coniferous forest. It sometimes hunts during the day and preys on large rodents and birds.

BROWN WOOD OWL
Strix leptogrammica
F: Strigidae

This owl occurs in lowland tropical forests throughout India and S.E. Asia. Hard to see, this wood owl can be recognized by its distinctive call.

URAL OWL
Strix uralensis
F: Strigidae

A relative of the great grey owl, this N. Eurasian species frequents coniferous and broadleaf forests, and may also enter towns.

TAWNY OWL
Strix aluco
F: Strigidae

Occurring throughout Eurasia, the tawny owl frequents farmland, towns, and gardens. It belongs to a group of related wood owls.

BARRED OWL
Strix varia
F: Strigidae

A large wood owl native to eastern N. America, this aggressive species is spreading westwards and displacing the smaller spotted owl.

SPOTTED OWL
Strix occidentalis
F: Strigidae

Native to western N. America, this wood owl occurs in mature coniferous forest, where it hunts flying squirrels and similar-sized prey.

DESERT EAGLE-OWL
Bubo ascalaphus
F: Strigidae

A bird of the Sahara Desert, this species is a smaller, paler, and longer-legged relative of the Eurasian eagle-owl.

RUFESCENT SCREECH OWL
Megascops ingens
F: Strigidae

This little-known bird from wet montane forests in northern S. America is larger than many other screech owls, and has smaller ears.

TROPICAL SCREECH OWL
Megascops choliba
F: Strigidae

The most widespread tropical American screech owl, this species occurs in a range from Costa Rica to Argentina. It exists in brown and grey forms.

GREAT HORNED OWL
Bubo virginianus
F: Strigidae

The most widespread American owl, this eagle-owl is found from Alaska to Argentina, in habitats as diverse as forest and desert.

EURASIAN EAGLE-OWL
Bubo bubo
F: Strigidae

One of the largest species of owl, this widespread eagle-owl occurs throughout Eurasia, and hunts animals as large as deer.

BLACK-CAPPED SCREECH OWL
Megascops atricapilla
F: Strigidae

Screech owls have diversified in forests throughout the Americas. Many have conspicuous ear tufts. This species is confined to C. and S. Brazil.

VERREAUX'S EAGLE-OWL
Bubo lacteus
F: Strigidae

This is the largest African owl. It is widespread south of the Sahara Desert, where it feeds on small game animals.

SOUTHERN WHITE-FACED OWL
Ptilopsis granti
F: Strigidae

Like many other owl species, this bird of sub-Saharan Africa breeds in the stick nests of other birds.

STRIPED OWL
Pseudoscops clamator
F: Strigidae

A S. American eared owl, this species lives in open, marshy habitats and nests in ground vegetation or low tree-holes.

NORTHERN HAWK-OWL
Surnia ulula
F: Strigidae

This relative of pygmy owls is found in subarctic forests. With its small head, long tail, and daytime activity, it is the most hawk-like owl.

ELF OWL
Micrathene whitneyi
F: Strigidae

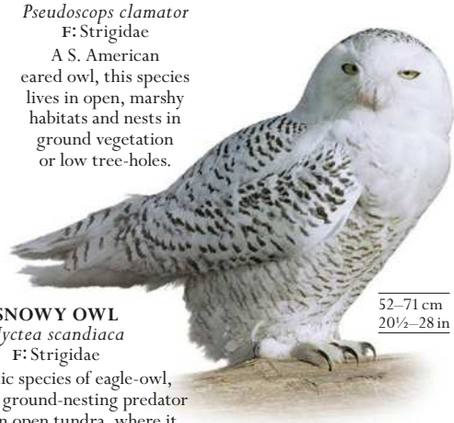
Like other insect-eaters, this tiny Mexican desert owl does not need to fly silently, so it lacks the fringed, sound-muffling wing feathers of larger species.

BUFFY FISH OWL
Ketupa ketupu
F: Strigidae

This S.E. Asian relative of eagle-owls catches fish and other aquatic prey with the help of its long-clawed feet.

SPECTACLED OWL
Pulsatrix perspicillata
F: Strigidae

This is a distinctive species from C. and S. American forests. Its fledglings are white with a contrasting black face.



SNOWY OWL
Nyctea scandiaca
F: Strigidae

An Arctic species of eagle-owl, this large, ground-nesting predator breeds on open tundra, where it feeds on lemmings and ptarmigan.

LEAST PYGMY OWL
Glaucidium minutissimum
F: Strigidae

Like other related small owls, this woodland bird of Paraguay and S.E. Brazil is active during the day and night.

NORTHERN PYGMY OWL
Glaucidium gnoma
F: Strigidae

Pygmy owls often fearlessly tackle prey bigger than themselves. This little predator from western N. America has been seen attacking grouse.

CUBAN PYGMY OWL
Glaucidium siju
F: Strigidae

Many owls nest in decayed tree cavities, but pygmy owls habitually choose old woodpecker holes. This species is restricted to Cuba.

FERRUGINOUS PYGMY OWL
Glaucidium brasilianum
F: Strigidae

Typical of pygmy owls, this American species has eyespots on the back of the head to confuse predators. It flicks its tail when excited.

»

» OWLS

21–28 cm
8½–11 in

TENGMALM'S OWL
Aegolius funereus
F: Strigidae

This owl of northern circumpolar forests is adept at locating small mammals under snow. It hunts during daylight.

19–25 cm
7½–10 in

BURROWING OWL
Athene cunicularia
F: Strigidae

A long-legged owl, this partly diurnal species inhabits grassland and deserts across the Americas, nesting in burrows of prairie dogs or other animals.

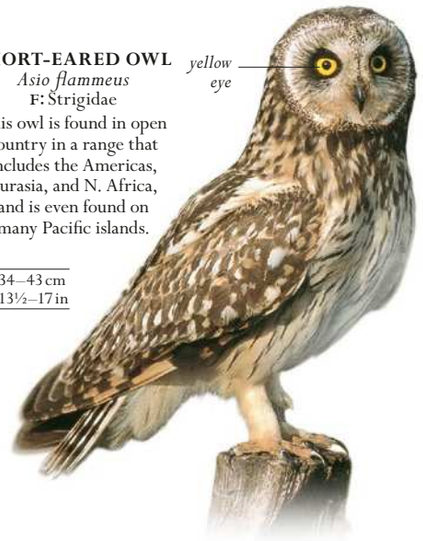
LONG-EARED OWL
Asio otus
F: Strigidae

Found in forests and heathland through much of the northern hemisphere, this owl can flatten its long ear tufts, rendering them invisible.

31–37 cm
12–14½ in

SHORT-EARED OWL
Asio flammeus
F: Strigidae

This owl is found in open country in a range that includes the Americas, Eurasia, and N. Africa, and is even found on many Pacific islands.

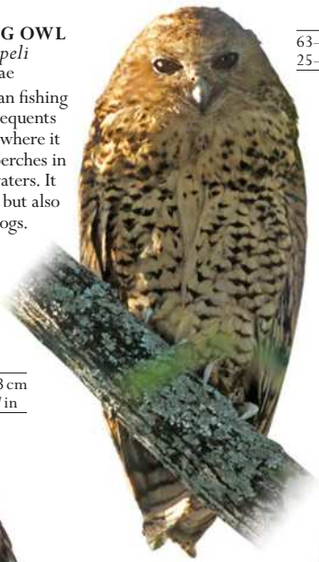


34–43 cm
13½–17 in

30–35 cm
12–14 in

MOREPORK
Ninox novaeseelandiae
F: Strigidae

Typical of Australasian hawk-owls, this bird has large, yellow eyes. Unusually for owls, the male of the species is larger than the female.



63–65 cm
25–26 in

PEL'S FISHING OWL
Scotopelia peli
F: Strigidae

The largest African fishing owl, this bird frequents riverside forest, where it hunts from low perches in slow-running waters. It eats mainly fish, but also crabs and frogs.

38–43 cm
15–17 in

BARKING OWL
Ninox connivens
F: Strigidae

Found from the Moluccas, Indonesia, to Australia, this woodland hawk-owl is named for its dog-like barking call.

38 cm
15 in

BLACK-AND-WHITE OWL
Ciccaba nigrolineata
F: Strigidae

This barred owl of dense tropical forests from Mexico to Ecuador is a close relative of the *Strix* wood owls.

MESITES

These small, insectivorous birds of forest and scrub in Madagascar are flightless, or almost so.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	MESITORNITHIFORMES
FAMILIES	1
SPECIES	3

In the family Mesitornithidae, mesites resemble passerines in their use of song for territorial defence, but they are social birds. Small groups often feed, rest, and preen together. Two species of the family are monogamous and their sexes look alike, while one is polygamous, with marked differences between the male and the female bird.

31 cm
12 in

WHITE-BREASTED MESITE
Mesitornis variegatus
F: Mesitornithidae

This bird is found in three isolated areas of undisturbed deciduous forest where small groups forage amongst leaf litter on the ground for insects, spiders, and seeds.

NIGHTJARS

All nightjars and their relatives are nocturnal. Most are insect-eaters, snatching their prey on the wing using an exceptionally wide bill gape.

Voracious predators by night, concealed by cryptic plumage during the day, nightjars have similarities to owls, and some ornithologists have thought the two groups to be related. Recent studies, however, link nightjars with swifts and hummingbirds. The connection is supported by features such as the weakness of their feet and the ability of some species to enter a torpid state.

Nightjars belong to the order Caprimulgiformes. Typically, they have a big head and long wings for quick aerial manoeuvres. Their short bill opens enormously wide to catch flying insects. The gape is particularly wide in the aptly named frogmouths from Australasia, which are predators of small vertebrates. Of the group, only the oilbird is vegetarian: a fruit-eater that roosts by day in caves.

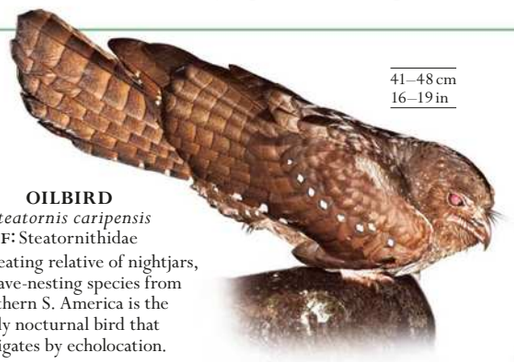
All these birds are masters of camouflage. Nightjars blend perfectly with forest litter when on the ground; in trees they perch lengthways on a branch to minimize detection. Frogmouths and potoos freeze when disturbed to mimic tree stumps, closing their eyes to complete the effect.

MINIMAL NESTS

All in this group are minimalist nesters. Nightjars simply lay their eggs in leaf litter on the ground. For oilbirds, a nest is a pile of droppings on a cave ledge, while potoos use nothing more than a depression on a branch.

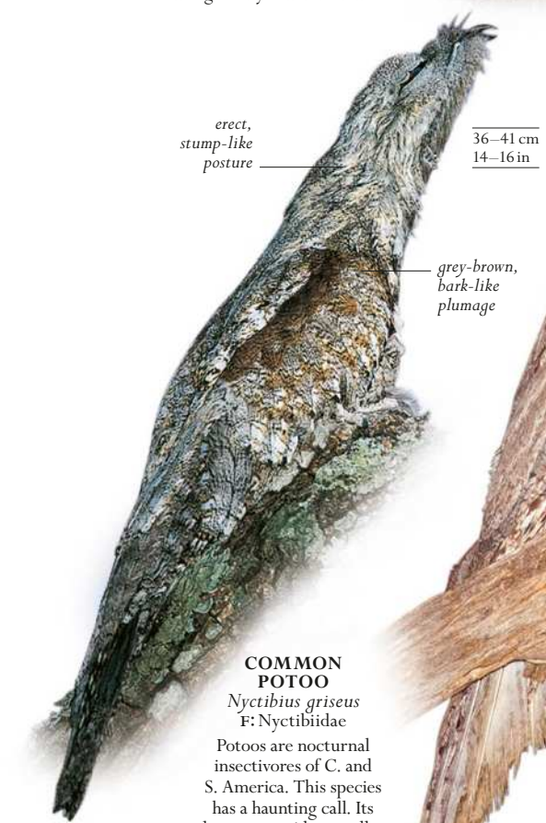
PHYLUM	CHORDATA
CLASS	AVES
ORDER	CAPRIMULGIFORMES
FAMILIES	4
SPECIES	122

A great potoo opens its enormous gape, displaying a key feature of a group of birds that can scoop up flying insects on the wing.



41–48 cm
16–19 in

OILBIRD
Steatornis caripensis
F: Steatornithidae
A fruit-eating relative of nightjars, this cave-nesting species from northern S. America is the only nocturnal bird that navigates by echolocation.



erect, stump-like posture

36–41 cm
14–16 in

grey-brown, bark-like plumage

COMMON POTOO
Nyctibius griseus
F: Nyctibiidae
Potoos are nocturnal insectivores of C. and S. America. This species has a haunting call. Its plumage provides excellent camouflage against tree bark.

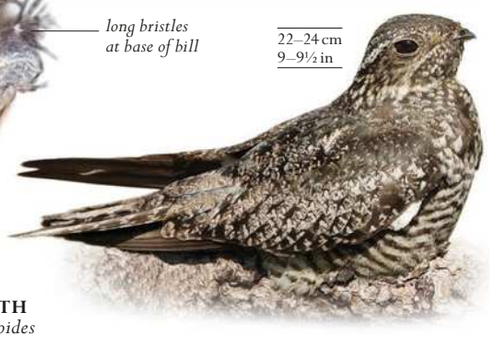
orange-yellow eye

long bristles at base of bill

grey mottled plumage

32–46 cm
12½–18 in

TAWNY FROGMOUTH
Podargus strigoides
F: Podargidae
This nocturnal Australian bird hunts from perches. Like other frogmouths, it roosts motionless during the day, resembling a broken branch.



22–24 cm
9–9½ in

COMMON NIGHTHAWK
Chordeiles minor
F: Caprimulgidae
Nighthawks lack the bill bristles of nightjars, and this absence perhaps helps in their aerial pursuit of insects. This insect-eater migrates between N. and S. America.

20 cm
8 in

OCELLATED POORWILL
Nyctiphrynus ocellatus
F: Caprimulgidae
Poorwills are small American nightjars, so called because of their mournful, monotonous calls. This dark-coloured species occurs in tropical forests.

19–21 cm
7½–8½ in

COMMON POORWILL
Phalaenoptilus nuttallii
F: Caprimulgidae
From arid parts of the USA and Mexico, this small nightjar is one of the few birds that enters a hibernation-like torpor in winter.

24–28 cm
9½–11 in

COMMON PAURAQUE
Nyctidromus albicollis
F: Caprimulgidae
This C. and S. American nighthawk frequents scrubby habitats. It is often seen resting on dirt roads at night.

EUROPEAN NIGHTJAR
Caprimulgus europaeus
F: Caprimulgidae
Like many nightjars of northern temperate regions, this species is migratory. Found in W. Eurasian heath and woodland, it overwinters in Africa.

SPOT-TAILED NIGHTJAR
Caprimulgus maculicaudus
F: Caprimulgidae
Found from Mexico to Paraguay, this species may be more closely related to tropical American nighthawks than Old World nightjars.

LARGE-TAILED NIGHTJAR
Caprimulgus macrurus
F: Caprimulgidae
Among the most widespread of the Old World nightjars, this species ranges from Pakistan to Australia and New Guinea.

PLAIN NIGHTJAR
Caprimulgus inornatus
F: Caprimulgidae
This African bird occurs from Mauritania to Saudi Arabia, and migrates south to Liberia, Congo, and Tanzania.

DUSKY NIGHTJAR
Caprimulgus saturatus
F: Caprimulgidae
Perhaps genetically closer to American poorwills than Old World nightjars, this species occurs in montane forests of Costa Rica and Panama.

LONG-TAILED NIGHTJAR
Caprimulgus climacurus
F: Caprimulgidae
The long tail of some nightjars may be used in a courtship display. This African species has a range from Senegal to Ethiopia.

LADDER-TAILED NIGHTJAR
Hydropsalis climacocerca
F: Caprimulgidae
This Amazonian species belongs to a group of S. American nightjars, in which males have a long, forked tail with white markings. These give the bird its name and are possibly used to attract females.

MADAGASCAR NIGHTJAR
Caprimulgus madagascariensis
F: Caprimulgidae
This nightjar from Madagascar and Aldabra Island (Seychelles) has a call that resembles the sound of a marble bouncing on a hard floor.

SHORT-TAILED NIGHTHAWK
Lurocalis semitorquatus
F: Caprimulgidae
One of several tropical American nighthawks, this bird has a short tail and long wings, which give it a bat-like appearance on its insect-chasing flights.

LONG-TRAINED NIGHTJAR
Macropsalis creagra
F: Caprimulgidae
Males of many nightjars have an elaborate tail. This species evolved from tropical American nighthawks and is limited to eastern S. America.

STANDARD-WINGED NIGHTJAR
Macrodipteryx longipennis
F: Caprimulgidae
This African species eats insects, including moths and beetles. Breeding males have flag-like flight feathers, longer than the body, which they raise in courtship displays.

HUMMINGBIRDS AND SWIFTS

The dashing flight of swifts – fastest of all birds – and the audible hovering of hummingbirds characterize the master aeronauts united in this order.

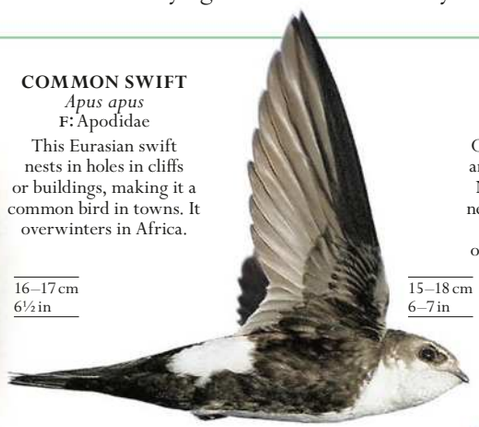
Both swifts and hummingbirds, members of the order Apodiformes, have tiny feet that are useful only for perching, but in compensation the birds have exceptional manoeuvrability on the wing. Swifts skim through the skies to catch flying insects.

Hummingbirds have the wing control to fly backwards, some of them whirring at over 70 wingbeats per second – sustained by a high metabolism fuelled by energy-rich nectar. Insects and spiders provide hummingbirds with protein to feed to their chicks. Hummingbirds use cobwebs to glue together their thimble-sized nests, while swifts use saliva. The swifts' range is almost worldwide, reaching oceanic islands. Hummingbirds are found only in the Americas.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	APODIFORMES
FAMILIES	4
SPECIES	405

COMMON SWIFT
Apus apus
F: Apodidae
This Eurasian swift nests in holes in cliffs or buildings, making it a common bird in towns. It overwinters in Africa.

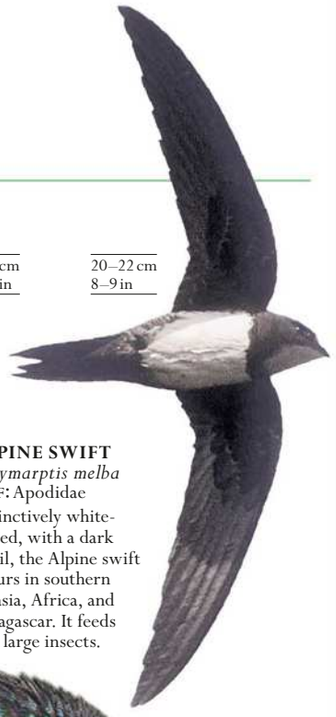
16–17 cm
6½ in



15–18 cm
6–7 in

CHIMNEY SWIFT
Chaetura pelagica
F: Apodidae
Originally nesting in caves and tree-holes, this eastern N. American species now nests primarily in chimneys in urban centres. It overwinters in S. America.

12–15 cm
4¾–6 in

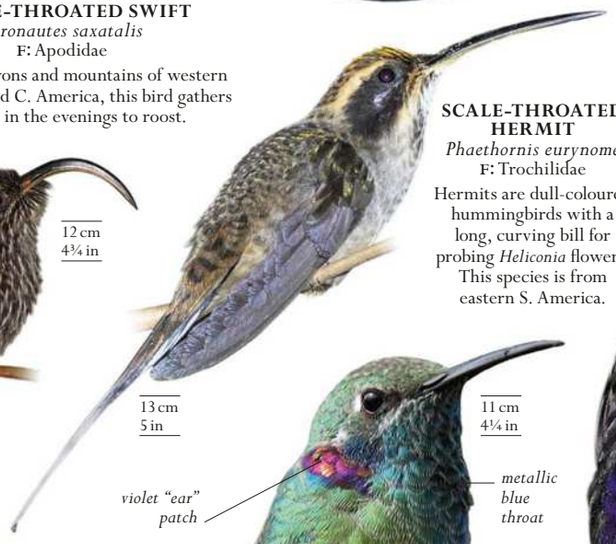


20–22 cm
8–9 in

ALPINE SWIFT
Tachymarptis melba
F: Apodidae
Distinctively white-bellied, with a dark undertail, the Alpine swift occurs in southern Eurasia, Africa, and Madagascar. It feeds on large insects.

WHITE-THROATED SWIFT
Aeronautes saxatalis
F: Apodidae
Found in canyons and mountains of western N. America and C. America, this bird gathers in flocks in the evenings to roost.

12 cm
4¾ in

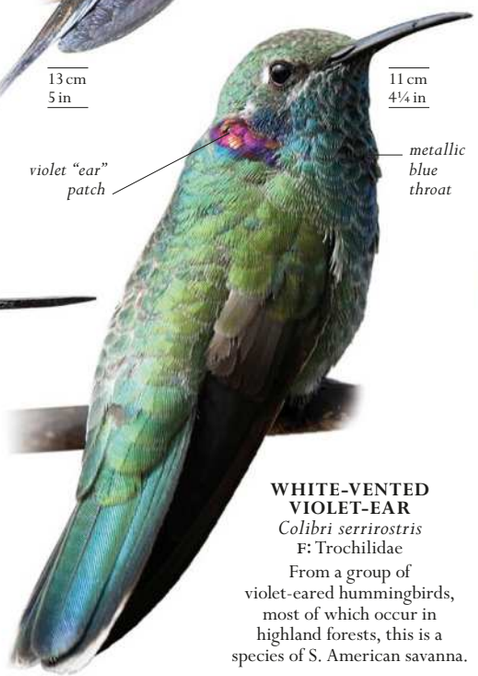


13 cm
5 in

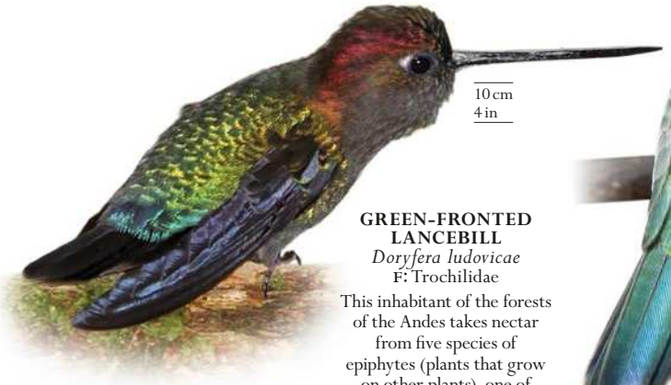
SCALE-THROATED HERMIT
Phaethornis eurynome
F: Trochilidae
Hermits are dull-coloured hummingbirds with a long, curving bill for probing *Heliconia* flowers. This species is from eastern S. America.

14–15 cm
5½–6 in

WHITE-TIPPED SICKLEBILL
Eutoxeres aquila
F: Trochilidae
This bird has a range that extends from Costa Rica to Peru. It uses its decurved bill to feed from similarly curved *Heliconia* flowers.



11 cm
4¼ in



10 cm
4 in

GREEN-FRONTED LANCEBILL
Doryfera ludovicae
F: Trochilidae
This inhabitant of the forests of the Andes takes nectar from five species of epiphytes (plants that grow on other plants), one of which is a mistletoe.

WHITE-VENTED VIOLET-EAR
Colibri serrirostris
F: Trochilidae
From a group of violet-eared hummingbirds, most of which occur in highland forests, this is a species of S. American savanna.

VIOLET SABREWING
Campylopterus hemileucurus
F: Trochilidae
Sabrewings are named for the thickened shafts of their flight feathers. This C. American bird is the largest hummingbird outside S. America.

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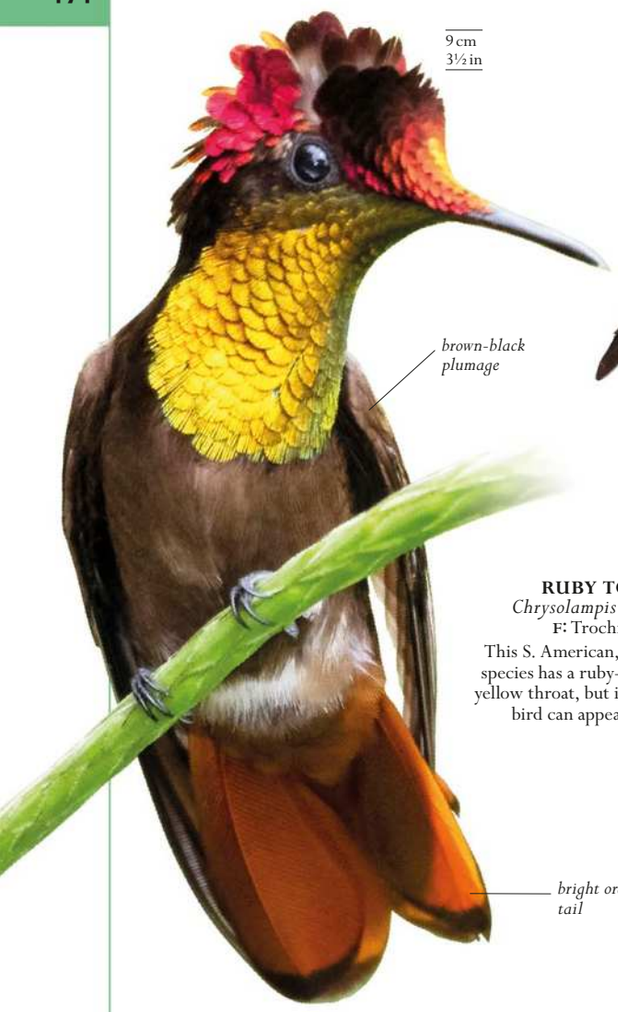


RUBY TOPAZ
Chrysolampis mosquitus
F: Trochilidae
This S. American, open-country species has a ruby-red crown and yellow throat, but in poor light the bird can appear all black.

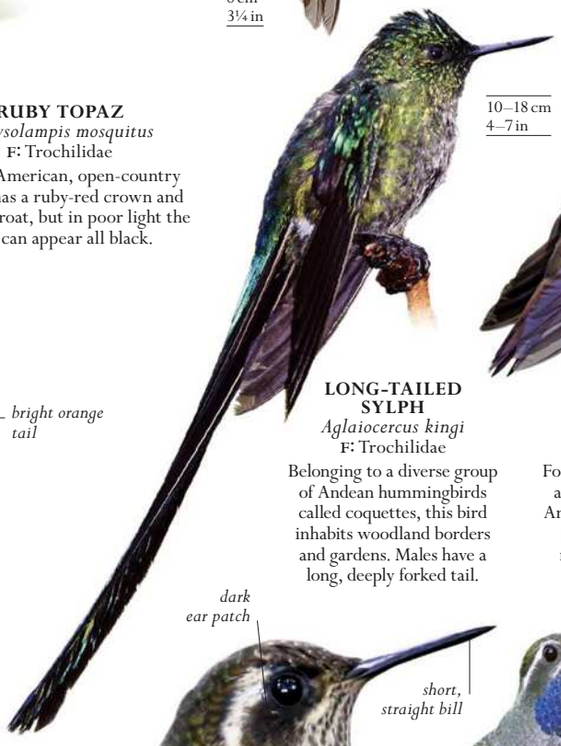
BLUE-CHINNED SAPPHIRE
Chlorostilbon notatus
F: Trochilidae
One of many emerald hummingbirds with metallic green plumage, this is a forest and farmland bird from northern S. America.

COLLARED INCA
Coeligena torquata
F: Trochilidae
Incas form a group of forest hummingbirds native to the Andes. The collared inca is one of the most widespread of the group, found from Colombia to Bolivia.

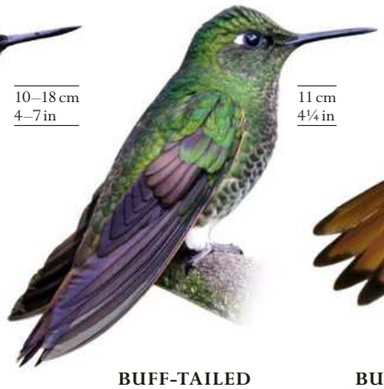
HOODED VISORBEARER
Augastes lumachella
F: Trochilidae
Visorbearers, with their green facial mask, are hummingbirds of arid habitats, such as highland savanna. This species occurs in E. Brazil.

BRAZILIAN RUBY
Clytolaema rubricauda
F: Trochilidae
Named for the male's brilliant ruby-red throat, this hummingbird is found in S.E. Brazil, but may be closely related to species found in the Andes.

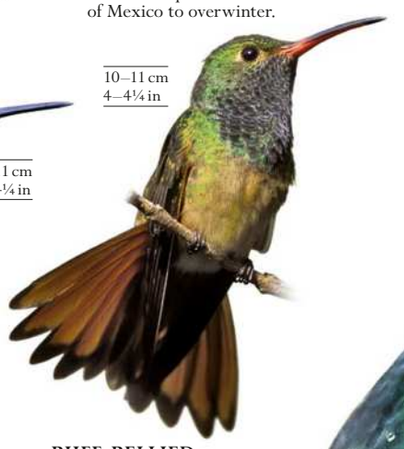
RUBY-THROATED HUMMINGBIRD
Archilochus colubris
F: Trochilidae
This tiny bee hummingbird is the eastern USA's only breeding hummingbird. It flies nonstop to the Gulf of Mexico to overwinter.



LONG-TAILED SYLPH
Aglaiocercus kingi
F: Trochilidae
Belonging to a diverse group of Andean hummingbirds called coquettes, this bird inhabits woodland borders and gardens. Males have a long, deeply forked tail.



BUFF-TAILED CORONET
Boissonneaua flavescens
F: Trochilidae
Found in Colombia, Venezuela, and Ecuador, this relative of Andean hummingbirds forages near flowering trees from mid-level to forest canopy, often with other birds.

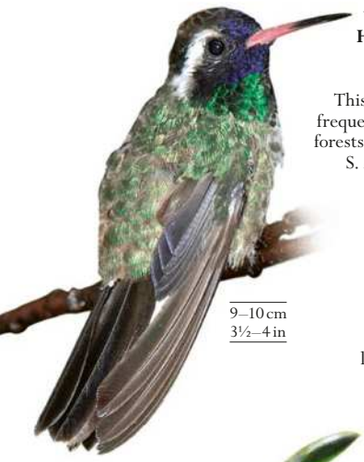


BUFF-BELLIED HUMMINGBIRD
Amazilia yucatanensis
F: Trochilidae
Belonging to a large group of emerald hummingbirds found in C. America, this bird is a Mexican species of open woodland.

SPECKLED HUMMINGBIRD
Adelomyia melanogenys
F: Trochilidae
A common hummingbird from the Andes, this species has duller plumage than many of its relatives in the coquette group. Both sexes are similar.

BLUE-THROATED HUMMINGBIRD
Lampornis clemenciae
F: Trochilidae
This large Mexican species belongs to a group of hummingbirds called mountain gems that originated in C. America. The northerly populations are migratory.

ANNA'S HUMMINGBIRD
Calypte anna
F: Trochilidae
A bee hummingbird of western N. America, this species overwinters further north than other hummingbirds. The bird feeds on nectar from a wide range of flowers.



WHITE-EARED HUMMINGBIRD
Basilinna leucotis
F: Trochilidae

This emerald hummingbird frequents pine and oak montane forests, often near streams, from S. Arizona to Nicaragua.

ANDEAN HILLSTAR
Oreotrochilus estella
F: Trochilidae

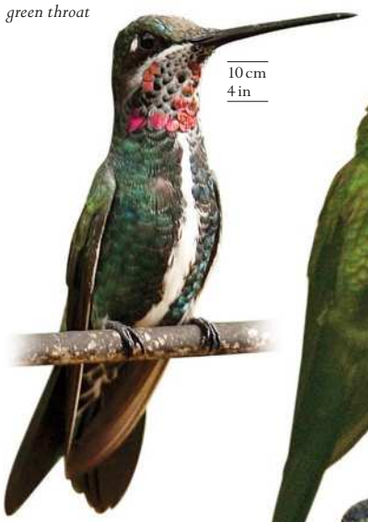
An Andean coquette hummingbird, this species lives higher than other species of the group, and feeds in air so thin that it cannot hover.

FORK-TAILED WOODNYMPH
Thalurania furcata
F: Trochilidae

A relative of the C. American emerald hummingbirds, this S. American species occurs in lowland forests as far south as N. Argentina.

WHITE-NECKED JACOBIN
Florisuga mellivora
F: Trochilidae

Genetic research suggests that this large, canopy-dwelling bird of tropical American lowlands belongs to a small lineage independent of other groups in its family.

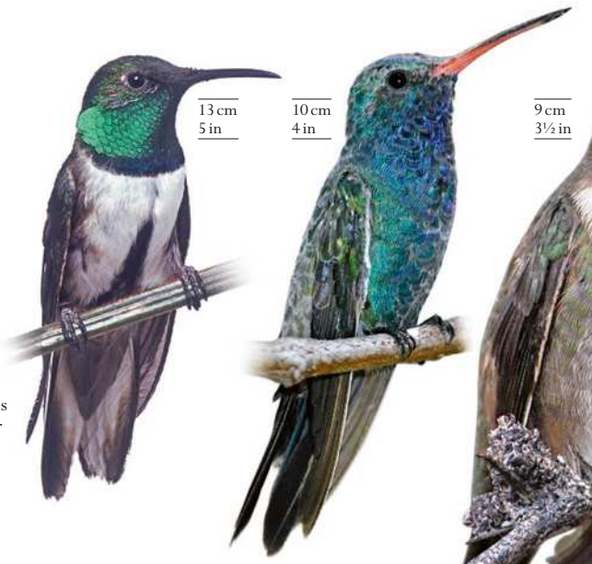


STRIPE-BREASTED STARTHROAT
Heliomaster squamosus
F: Trochilidae

Male starthroats have a vividly coloured band around their throat. Although starthroats are related to C. American mountain gems, this species is from eastern Brazil.

GORGETED SUNANGEL
Heliangelus strophianus
F: Trochilidae

Sunangels belong to the coquette group of Andean hummingbirds. This species is found from Colombia to Ecuador and lives in wet forest thickets.



BROAD-BILLED HUMMINGBIRD
Cynanthus latirostris
F: Trochilidae

Males of this Mexican scrub hummingbird fly back and forth in a pendulum display to attract females. The species belongs to the "emerald" group.

SWORD-BILLED HUMMINGBIRD
Ensifera ensifera
F: Trochilidae

The only bird with a bill longer than its body, this member of the Andean inca group favours the trumpet-shaped flowers of passion vines.

LUCIFER HUMMINGBIRD
Calothorax lucifer
F: Trochilidae

This bee hummingbird is found in a range from the southern USA to Mexico. It lives in semi-deserts, especially those with *Agave* plants.

BEE HUMMINGBIRD
Mellisuga helenae
F: Trochilidae

This tiny hummingbird is confined to Cuba, but is related to migratory N. American hummingbirds. Males of the species are the smallest of all birds.

RACKET-TAILED PUFFLEG
Ocreatus underwoodii
F: Trochilidae

Belonging to the inca group, this bee-sized hummingbird of Andean forests is attracted to brush blossoms, such as those of legumes.

RUFOUS HUMMINGBIRD
Selasphorus rufus
F: Trochilidae

Sustaining the longest migration of comparably small birds, this aggressively territorial bee hummingbird takes a route from Alaska to Mexico.

CALLIOPE HUMMINGBIRD
Stellula calliope
F: Trochilidae

One of the migratory bee hummingbirds, this bird breeds in open forests of western N. America and overwinters in the Mexican semi-desert.

PLOVERCREST
Stephanoxis lalandi
F: Trochilidae

This distinctive bird may be related to larger sabrewings of C. America, but is found in montane forests of eastern S. America.

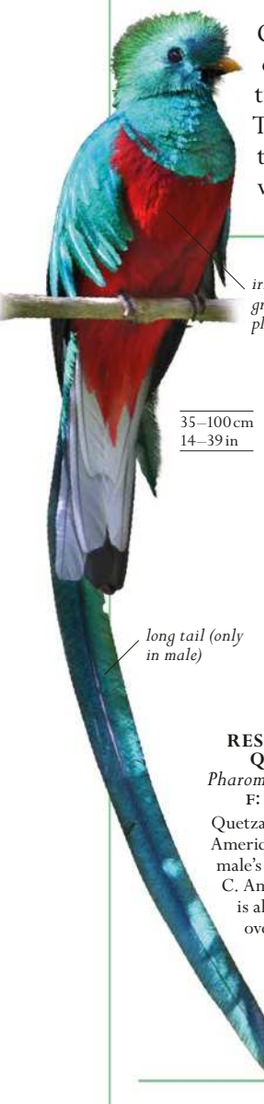
TROGONS

Gaudily coloured birds of tropical forests, the fruit-eating trogons have a wide bill, delicate plumage, and a foot structure unique to this group.

Crow-sized birds belonging to the order Trogoniformes are found in tropical America, Africa, and Asia. The males have brighter plumage than the females. Long-tailed and short-winged, trogons are capable fliers, though reluctant to break cover. The first and second toes of a trogon's foot face backwards whereas the third and fourth toes face forwards. This arrangement is seen in no other birds. These unusual feet are so weak that a trogon can barely manage more than a shuffle when perched.

Trogons use their wide bill for tackling large fruit and taking invertebrates such as caterpillars. They also use their bill for excavating nesting holes in rotten wood and termite mounds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	TROGONIFORMES
FAMILIES	1
SPECIES	43



35–100 cm
14–39 in

RESPLENDENT QUETZAL
Pharomachrus mocinno
F: Trogonidae
Quetzals are iridescent American trogons. The male's long tail in this C. American species is almost half its overall length.

31–36 cm
12–14 in

RED-HEADED TROGON
Harpactes erythrocephalus
F: Trogonidae
An Asian trogon found from the Himalayas to Sumatra, this elusive bird, like many of its cousins, perches motionless for long periods.

27–32 cm
10½–12½ in

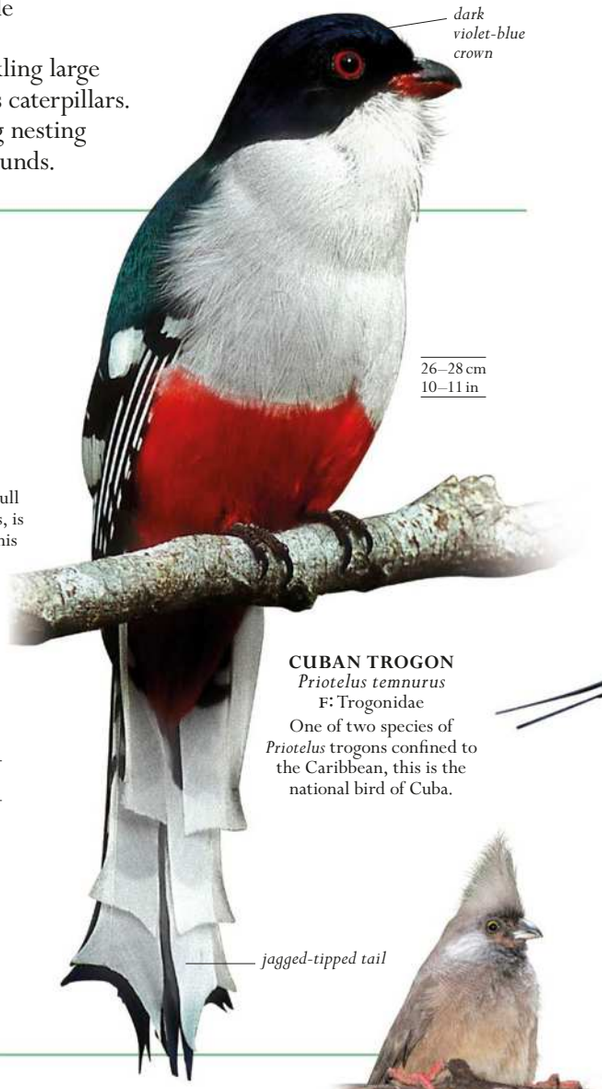
ORANGE-BREASTED TROGON
Harpactes oreskios
F: Trogonidae
The colour pattern of this bird, dull upperparts, and bright underparts, is typical of many Asian trogons. This species is a native of S.E. Asia.

28–30 cm
11–12 in

ELEGANT TROGON
Trogon elegans
F: Trogonidae
The only trogon with a range that extends to the USA, this bird occurs in montane forests from southern Arizona to C. America.

25–27 cm
10–10½ in

MASKED TROGON
Trogon personatus
F: Trogonidae
Males of this species from S. American montane forests have plumage that resembles that of the elegant trogon.



26–28 cm
10–11 in

CUBAN TROGON
Priotelus temnurus
F: Trogonidae
One of two species of *Priotelus* trogons confined to the Caribbean, this is the national bird of Cuba.

MOUSEBIRDS

Named for their scurrying, rodent-like behaviour, the mousebirds are a small group of drab-coloured, long-tailed birds confined to sub-Saharan Africa.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	COLIIFORMES
FAMILIES	1
SPECIES	6

Mousebirds, the sole family of the order Coliiformes, are softly feathered in shades of brown or grey and have an erectile crest and long tail. Gregarious and agile, they resemble parakeets in behaviour. These tree-dwelling birds build twiggy, cup-shaped nests. The chicks hatch at an advanced stage of development and quickly master flight. Ornithologists think that mousebirds are the remnant of a more diverse group that, in prehistoric times, ranged beyond Africa. Fossil mousebirds have been found in Europe. Their relationship to other birds is uncertain: mousebirds could be allied with trogons, kingfishers, or woodpeckers.

30–35 cm
12–14 in

SPECKLED MOUSEBIRD
Colius striatus
F: Coliidae
The largest and one of the most widespread of mousebirds, this species occurs from Nigeria to South Africa in savanna and open woodland.

33–35 cm
13–14 in

BLUE-NAPED MOUSEBIRD
Urocolius macrourus
F: Coliidae
Urocolius mousebirds are stronger fliers and less "mouse-like" than *Colius* mousebirds. This scrubland dweller is found from Senegal to Tanzania.

KINGFISHERS AND RELATIVES

This order, Coraciiformes, has a worldwide distribution. All members perch with three toes pointing forward, as do the Passerines, but their two outer toes are fused at the base.

Kingfishers often have bright green or blue colours, created not by pigments but by the scattering of light from the microstructure of their feathers. They follow diverse lifestyles, not all reflected in the popular English name. Fish-eating species locate prey by sight and dive onto it, either from a fixed perch or after a hover in mid-air. Others also hunt land animals, including lizards, rodents, and insects. A large head and a strong neck helps these birds to dive efficiently, and their sharp-edged, long bill helps grip slippery prey. Fish-eaters have a slender bill, while a broader, scoop-like bill is a feature of woodland kingfishers that catch their prey directly from dry ground. Their short legs are ideal for perching, but kingfishers cannot walk. Their feet are, however, also used for excavating elongated nesting cavities in earth or sand banks.

OTHER RELATIVES

Other members of this order, the American motmots and the Old World rollers, are all land hunters. All kingfisher relatives display a wide variety of bill shapes. In the aerial-hunting bee-eaters, the long bill holds stinging insects away from the head, and is used like forceps to squeeze out insect venom.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CORACIIFORMES
FAMILIES	6
SPECIES	177

Despite their dagger-like bill, kingfishers grasp prey, rather than stab it, like almost all other fish-eating birds.

LILAC-BREASTED ROLLER
Coracias caudatus
F: Coraciidae

Like other *Coracias* rollers, this African bird is a predator of ground animals, swooping to take lizards, rodents, and large invertebrates.

32–36 cm
12½–14 in

28–30 cm
11–12 in

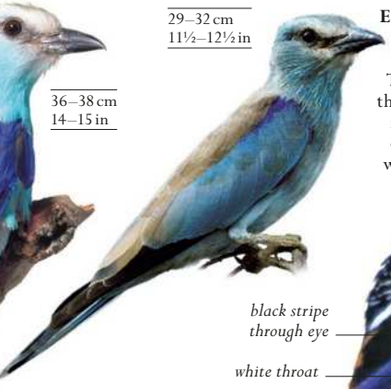
BLUE-BELLIED ROLLER
Coracias cyanogaster
F: Coraciidae

This C. African roller, like many of its relatives, nests in tree cavities. It is common throughout its extensive range.

36–38 cm
14–15 in

RACQUET-TAILED ROLLER
Coracias spatulatus
F: Coraciidae

This distinctive fork-tailed roller from E.Africa has outer tail feathers with projecting "flag-tipped" vanes.



29–32 cm
11½–12½ in

EUROPEAN ROLLER
Coracias garrulus
F: Coraciidae

The most widespread of the *Coracias* rollers, named for their somersaulting courtship displays, this western Eurasian species overwinters in Africa.

36–41 cm
14–16 in

RUFOUS-CROWNED ROLLER
Coracias naevius
F: Coraciidae

Somewhat dull coloured compared with other species, this large roller inhabits arid areas across sub-Saharan Africa.

DOLLARBIRD
Eurystomus orientalis
F: Coraciidae

Named for its pale, dollar-shaped underwing markings, this roller occurs in woodland from the Himalayas to Australia.

27–30 cm
10½–12 in

yellow bill

BROAD-BILLED ROLLER
Eurystomus glaucurus
F: Coraciidae

Typical of its genus, this African species is longer winged and more agile in pursuit of flying prey than *Coracias* rollers.

27–30 cm
10½–12 in

long, brown tail with dark barring

47–52 cm
18½–20½ in

LONG-TAILED GROUND ROLLER
Uratelornis chimaera
F: Brachypteraciidae

Like other ground rollers, this species from the dry forests of S.W. Madagascar nests in holes excavated in the ground.

black stripe through eye

white throat

PITTA-LIKE GROUND ROLLER
Atelornis pittoides
F: Brachypteraciidae

As the name suggests, ground rollers are mostly terrestrial. This rainforest species is the most brightly coloured of the family.

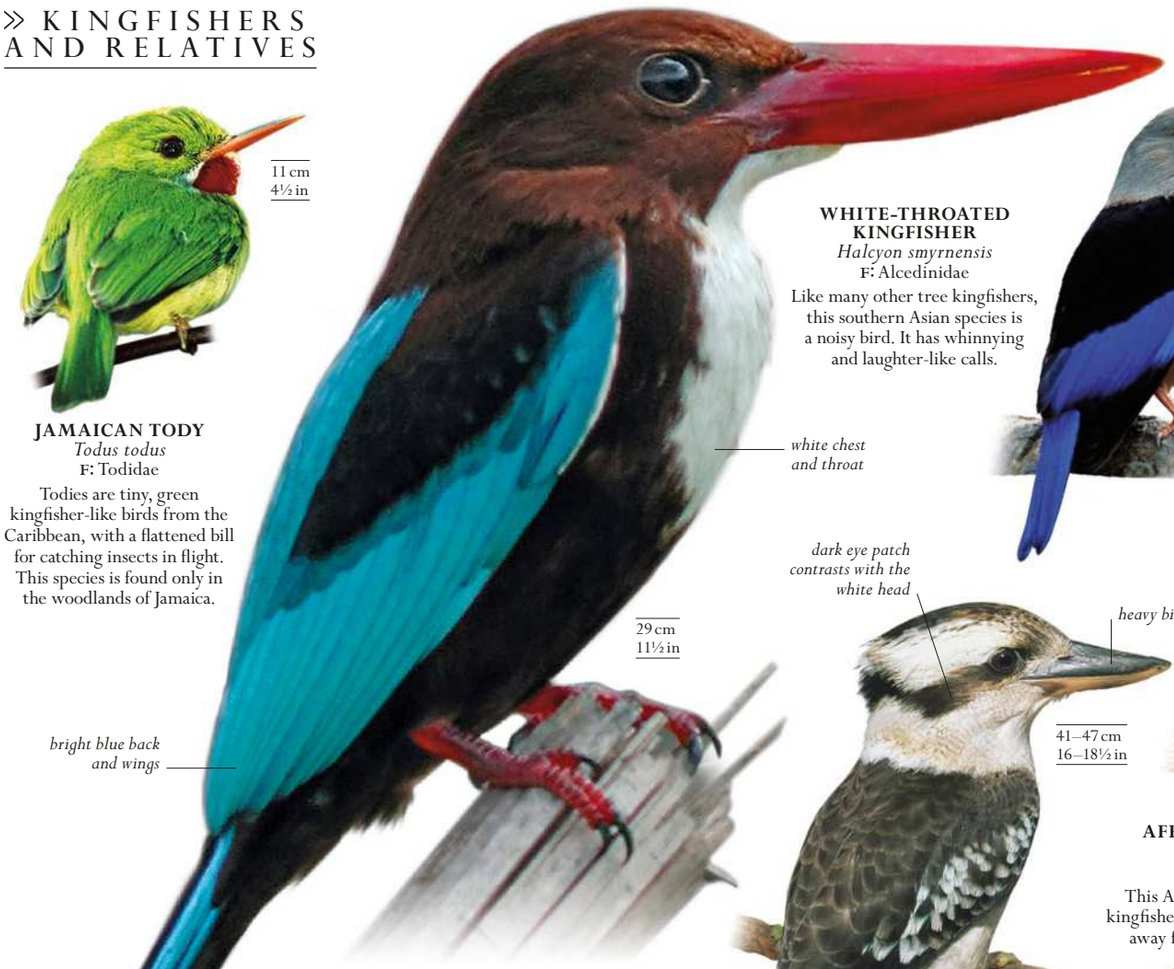
26 cm
10 in

» KINGFISHERS AND RELATIVES

11 cm
4½ in

JAMAICAN TODY
Todus todus
F: Todidae

Todies are tiny, green kingfisher-like birds from the Caribbean, with a flattened bill for catching insects in flight. This species is found only in the woodlands of Jamaica.



29 cm
11½ in

WHITE-THROATED KINGFISHER
Halcyon smyrnensis
F: Alcedinidae

Like many other tree kingfishers, this southern Asian species is a noisy bird. It has whinnying and laughter-like calls.

20 cm
8 in

GREY-HEADED KINGFISHER
Halcyon leucocephala
F: Alcedinidae

Tree kingfishers are a group of mainly insect-eating forest birds. The grey-headed kingfisher is an African species that may also eat fish.

41–47 cm
16–18½ in

12–13 cm
4¾–5 in

AFRICAN PYGMY KINGFISHER
Ispidina picta
F: Alcedinidae

This African bird belongs to a group of river kingfishers, but mainly feeds on insects so occurs away from water in woodland and savanna.

18–20 cm
7–8 in

GREEN KINGFISHER
Chloroceryle americana
F: Alcedinidae

A tropical American bird, this water kingfisher plunge-dives for fish and aquatic insects and often perches on rocks in streambeds.

LAUGHING KOOKABURRA
Dacelo novaeguineae
F: Alcedinidae

Widespread in Australian woodland, this large tree kingfisher preys on reptiles as well as invertebrates, and has a loud chuckling call.

18–21 cm
7–8½ in

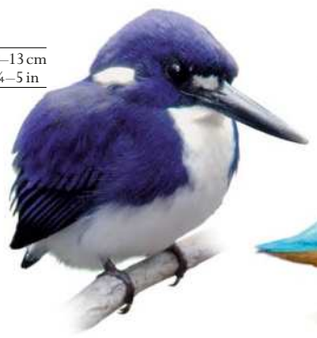
YELLOW-BILLED KINGFISHER
Syma torotoro
F: Alcedinidae

This tree kingfisher occurs in rainforests of New Guinea and N. Australia. It feeds mainly on insects, but also eats worms and small lizards.

17–19 cm
6½–7½ in

AZURE KINGFISHER
Ceyx azureus
F: Alcedinidae

Like other river kingfishers, the azure kingfisher nests in holes along riverbanks. It is found in creeks and mangroves in Australia and New Guinea.



12–13 cm
4¾–5 in

LITTLE KINGFISHER
Ceyx pusillus
F: Alcedinidae

This tiny Australasian species of mangroves is a river kingfisher. It eats tiny fish, insect larvae, small crustaceans, and shrimps.

16–17 cm
6½ in

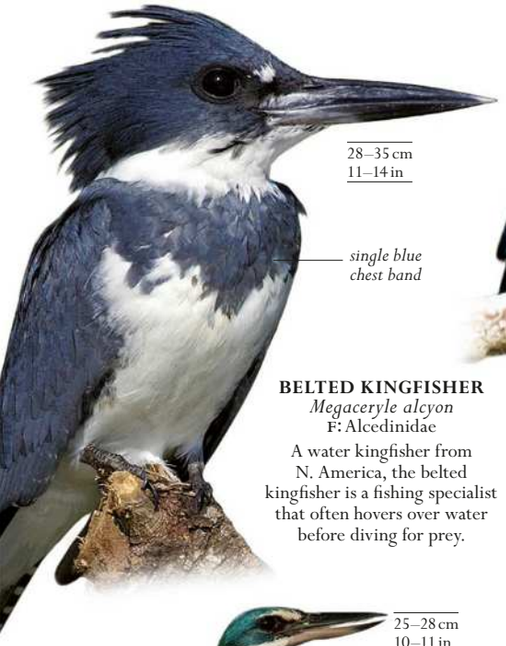
COMMON KINGFISHER
Alcedo atthis
F: Alcedinidae

Found in Eurasia and N. Africa, this bird is typical of a group of diminutive, short-tailed river kingfishers from the Old World.

28–29 cm
11–11½ in

PIED KINGFISHER
Ceryle rudis
F: Alcedinidae

From Africa and S. Asia, this water kingfisher of rivers and lakes often gathers in small groups. It can hover in one spot for long periods of time.



BELTED KINGFISHER
Megaceryle alcyon
F: Alcedinidae

A water kingfisher from N. America, the belted kingfisher is a fishing specialist that often hovers over water before diving for prey.

BUFF-BREASTED PARADISE KINGFISHER
Tanysiptera sylvia
F: Alcedinidae

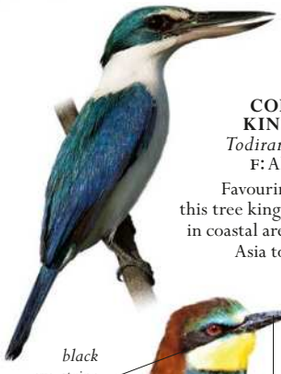
Many tree kingfishers, such as this species from New Guinea and N. Australia, nest in holes in tree-top termite mounds.

BROWN-WINGED KINGFISHER
Pelargopsis amauroptera
F: Alcedinidae

A tree kingfisher of mangrove forests, this species occupies a range from India to the Malay Peninsula.

STORK-BILLED KINGFISHER
Pelargopsis capensis
F: Alcedinidae

Occurring in southern Asia, this bird is found near water in forests, especially outside the range of the related brown-winged kingfisher.



COLLARED KINGFISHER
Todiramphus chloris
F: Alcedinidae

Favouring mangroves, this tree kingfisher is widespread in coastal areas across southern Asia to the Pacific.

RUFOUS MOTMOT
Baryphthengus martii
F: Momotidae

Like other motmots, this stout-billed bird from C. and northern S. America sallies for large insects and small vertebrates.

BLUE-CROWNED MOTMOT
Momotus momota
F: Momotidae

Like the related bee-eaters and many kingfishers, this typical brightly coloured motmot from tropical America nests in tunnels in riverbanks.

TURQUOISE-BROWED MOTMOT
Eumomota superciliosa
F: Momotidae

As with other motmots, the racket-tipped tail of this C. American motmot is formed by weakened feather barbs that break away.

EUROPEAN BEE-EATER
Merops apiaster
F: Meropidae

Like other bee-eaters, this bird from southwestern Eurasia and Africa catches insects in flight. Before eating bees, it removes the sting from its prey.

RAINBOW BEE-EATER
Merops ornatus
F: Meropidae

The only bee-eater in Australia, southernmost populations of this species migrate northwards to overwinter in northern Australia and Indonesia.

WHITE-FRONTED BEE-EATER
Merops bullockoides
F: Meropidae

This African bee-eater breeds in large colonies, which have a complex social system with non-breeding birds assisting in raising the young.

GREEN BEE-EATER
Merops orientalis
F: Meropidae

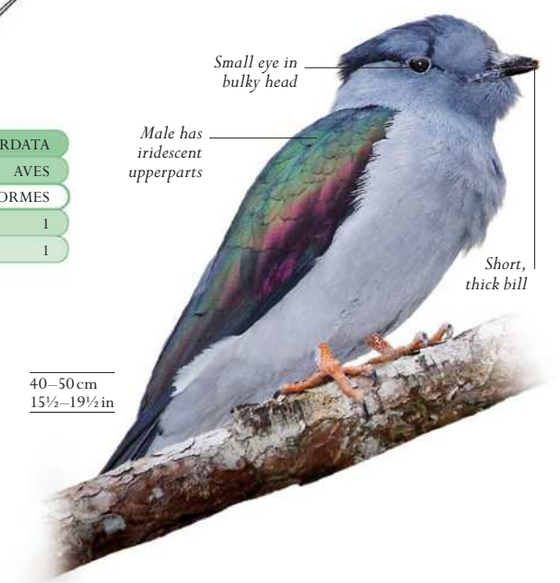
Found in dry, open habitats in Africa and S. Asia, the green bee-eater nests in looser colonies than other species of bee-eater.

CUCKOO-ROLLER

Comprising a single rare species from the Madagascar forest, the order Leptosomiformes is placed close to the quetzals of South America, though its affinity to other orders is unclear.

The cuckoo-roller, which survives in fragmented remnant forests, seems less endangered than many other Madagascan species. It feeds like a flycatcher on large insects, but also eats small reptiles. Similar to cuckoos, it is able to digest hairy caterpillars, which most species avoid. Again similar to cuckoos, its two toes face forward and two backwards.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	LEPTOSOMIFORMES
FAMILIES	1
SPECIES	1



CUCKOO-ROLLER
Leptosomus discolor
F: Leptosomatidae

Superficially resembling a cuckoo, this Madagascan predator of small animals is not closely related to true rollers. It nests in tree cavities.

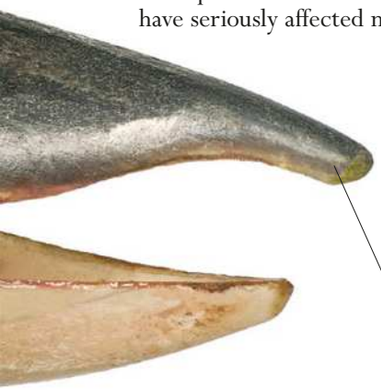
SHOVEL-BILLED ASSASSIN ∨
A bold, dry-land, woodland-edge kingfisher, the laughing kookaburra sits on an exposed perch looking for prey. It uses its shovel-shaped bill and muscular neck to grab small snakes and rodents, hitting larger prey against the ground to subdue them.

spiky crown feathers form short crest
broad dark cheek-patch below large eye
lower mandible used to scoop up small prey
white underside helps hide the bird against the sky from prey below

LAUGHING KOOKABURRA
Dacelo novaeguineae

Laughing kookaburras are famously vocal. A first loud, chuckling laugh spreads into a loud chorus from several birds, the staccato notes echoing through the Australian bush. "Laughing jackass" was a popular nickname for this large-headed, short-legged bird; another, "bushman's clock", reflects the regularity of calls at dawn and dusk. Its nest is an unlined hollow in a tree stump or in a hole excavated with its bill in a termite mound. Like other kingfishers, its three to five eggs are pure white. If food is short, the final egg is small and the resultant weak chick is likely to be killed by its stronger siblings. Adult laughing kookaburras form life-long pair bonds, but are helped at the nest by up to five immature birds from previous years, and all may incubate the eggs and then brood and feed the chicks. This species is widespread and relatively common, but recent wildfires in Australian woodland have seriously affected many populations.

SIZE 41–47cm (16–18½in)
HABITAT Open, bushy woodland and eucalypt forest
DISTRIBUTION Eastern Australia, introduced in other parts of Australia and New Zealand
DIET Lizards, snakes, small mammals, insects, worms, snails, and other invertebrates



upper mandible tapers to a slender point

EYE >
A sensitive area of the retina in each eye allows exceptionally sharp vision. The laughing kookaburra moves its head to align a second sensitive area in each eye to give binocular vision when searching for prey below.

∨ TONGUE
The broad, pointed tongue sits neatly inside the deep lower mandible. Sticky with mucous, it has a small "hook" at the rear, and helps to manipulate and swallow wriggling or muscular prey items.

∨ FOOT
As with other kingfishers, the long outer toe and middle toe are fused together. The very short leg gives a secure, upright stance on a perch, but means the laughing kookaburra can only shuffle when on the ground.

< NOSTRIL
An open nostril high at the base of the bill minimizes the risk of clogging by sand or mud. The long, bristly feathers behind it help protect the eye.

TAIL ∨
The laughing kookaburra's tail is long for a kingfisher. In flight, the tail is spread wide revealing all 12 feathers.

outer tail feathers have more white bands than inner feathers

WING ^
Short and broad, the wing is curved into an aerofoil: the thick, muscular inner "arm" tapers to flat, blade-like flight feathers behind and at the tip.

HORNBILLS, HOOPOES, AND WOOD HOOPOES

Hornbills (including some giants of the bird world), hoopoes, wood hoopoes, and the similar scimitarbills form an Old World order, the Bucerotiformes, some boldly coloured and all strikingly patterned and distinctive in form.

Hoopoes walk on the ground and probe for invertebrates and small reptiles with their slender, curved bill, while wood hoopoes hop on trees and probe inside loose bark. Hornbills have a larger, longer bill, some with a large, horny adornment on top. They range from medium-sized to very large forest species. Ground hornbills are extremely large, heavy birds that feed exclusively on the ground. Some hornbills nest in tree holes and males seal the females inside with mud, feeding them through a narrow slit until the young hatch.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	BUCEROTIFORMES
FAMILIES	4
SPECIES	74

reddish bill
grey, white, and black plumage
white underparts
black-tipped crest, raised when landing
black and white bars on wings

42–45 cm
16½–18 in

RED-BILLED HORNBILL
Tockus erythrorhynchus
F: Bucerotidae

Tockus hornbills are small African predators, most with a red or yellow bill. This species inhabits savanna and open woodland from Senegal to Namibia.

58–65 cm
23–26 in

TRUMPETER HORNBILL
Bycanistes bucinator
F: Bucerotidae

This hornbill inhabits the forests of eastern to southern Africa. It is similar to the related silvery-cheeked hornbill, but has red facial skin.

75–80 cm
30–32 in

SILVERY-CHEEKED HORNBILL
Bycanistes brevis
F: Bucerotidae

This fruit-eating pied hornbill is a forest species from E. Africa. As with other hornbills, the male has a larger bill than the female, with a more prominent casque.

70 cm
28 in

ORIENTAL PIED HORNBILL
Anthracoceros albirostris
F: Bucerotidae

The most widespread of the Asian pied hornbills, this bird occurs from the Himalayas to Bali (Indonesia), in cultivated land as well as forest.

1 m
3¼ in

25–32 cm
10–12½ in

30–36 cm
12–14 in

70 cm
28 in

MALABAR PIED HORNBILL
Anthracoceros coronatus
F: Bucerotidae

Like most other Asian hornbills, this pied species from India and Sri Lanka is omnivorous, and eats a great deal of fruit.

NORTHERN GROUND HORNBILL
Bucorvus abyssinicus
F: Bucorvidae

One of two predatory ground hornbills of African grasslands, this species from Senegal to Kenya tolerates drier conditions than its southern counterpart.

HOOPOE
Upupa epops
F: Upupidae

This species nests in tree-holes in Africa and Eurasia. It has a flickering, butterfly-like flight and a strong bill to dig for ground-living invertebrates.

GREEN WOOD HOOPOE
Phoeniculus purpureus
F: Phoeniculidae

This African wood hoopoe climbs trees like a woodpecker, but has a hoopoe-like bill to probe rotting wood for invertebrates.

WOODPECKERS AND TOUCANS

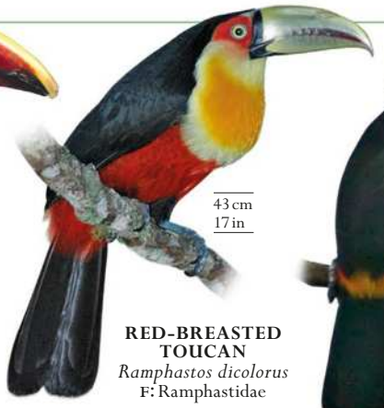
Mostly tree-dwelling cavity nesters, birds of this order, the Piciformes, have a common foot structure. More than half of the species are woodpeckers.

The woodpeckers are almost worldwide in distribution. These birds cling to trunks with zygodactyl feet typical of the order (two toes pointing forwards, two backwards) and, propped by their stiffened tail, drum through the wood with their strong bill. They extract prey with a long barbed tongue. Other birds in the order are largely confined to the tropics. Honeyguides feed on the wax from raided bee nests. Jacamars hunt large insects while puffbirds are flycatchers. Barbets have a serrated bill for eating fruits; the tropical American barbets are cousins of the toucans. Honeyguides are brood parasites, laying eggs in the nests of other birds, including woodpeckers. Others in this group nest in tree-holes, or may dig out burrows in the ground or in termite mounds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PICIFORMES
FAMILIES	9
SPECIES	445

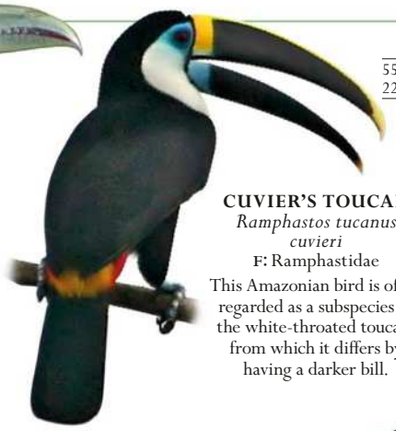
53–60 cm
21–23½ in

WHITE-THROATED TOUCAN
Ramphastos tucanus
F: Ramphastidae
Like other toucans, this species from northern S. America breeds in tree cavities, often making use of abandoned woodpecker nests.



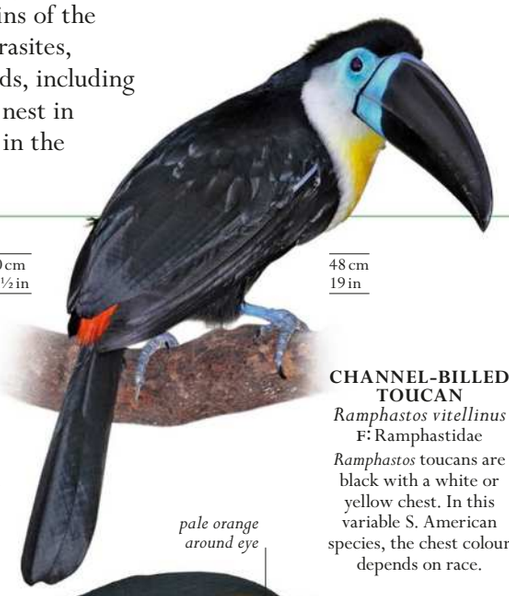
43 cm
17 in

RED-BREASTED TOUCAN
Ramphastos dicolorus
F: Ramphastidae
Among the smallest of the *Ramphastos* toucans, this species from eastern S. America is the only one with extensive red underparts.



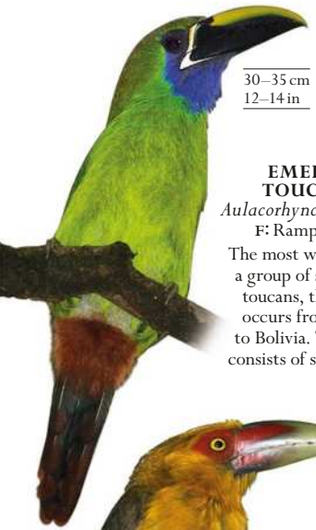
55–60 cm
22–23½ in

CUVIER'S TOUCAN
Ramphastos tucanus cuvieri
F: Ramphastidae
This Amazonian bird is often regarded as a subspecies of the white-throated toucan, from which it differs by having a darker bill.



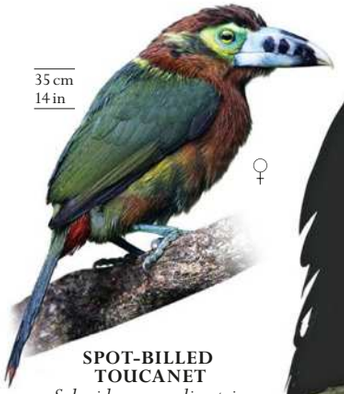
48 cm
19 in

CHANNEL-BILLED TOUCAN
Ramphastos vitellinus
F: Ramphastidae
Ramphastos toucans are black with a white or yellow chest. In this variable S. American species, the chest colour depends on race.



30–35 cm
12–14 in

EMERALD TOUCANET
Aulacorhynchus prasinus
F: Ramphastidae
The most widespread of a group of small green toucans, this species occurs from Mexico to Bolivia. The species consists of several races.



35 cm
14 in

♀

SPOT-BILLED TOUCANET
Selenidera maculirostris
F: Ramphastidae
This S. Brazilian species is one of several dichromatic toucanets, which are the only toucans with different-coloured sexes. The females are marked with brown.

pale orange around eye

55–65 cm
22–26 in

TOCO TOUCAN
Ramphastos toco
F: Ramphastidae
This bird from northern S. America is the largest of the toucans. Unlike other forest species, it also inhabits more open woodland habitats.

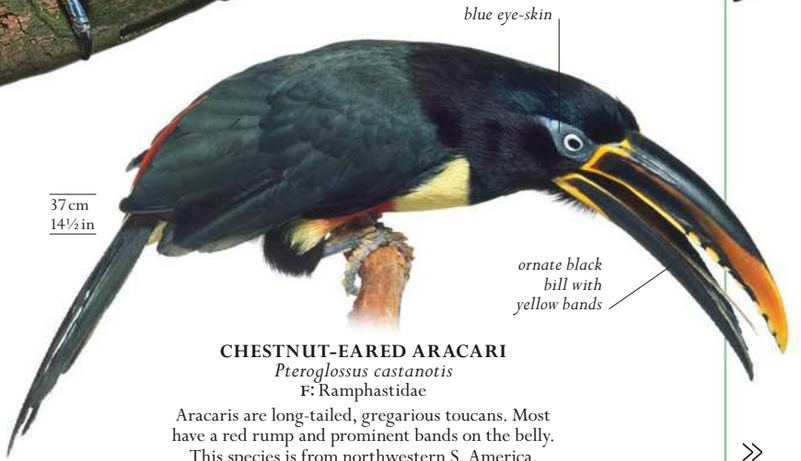
massive, black-tipped orange bill

35–40 cm
14–16 in

SAFFRON TOUCANET
Pteroglossus bailloni
F: Ramphastidae
Found in S.E. Brazil, this toucan has a yellow-olive plumage. It is related to the more brightly coloured aracaris.

41 cm
16 in

COLLARED ARACARI
Pteroglossus torquatus
F: Ramphastidae
With the most northerly range of the aracaris, this species occurs in humid forests from S. Mexico to northern S. America.



37 cm
14½ in

blue eye-skin

ornate black bill with yellow bands

CHESTNUT-EARED ARACARI
Pteroglossus castanotis
F: Ramphastidae
Aracaris are long-tailed, gregarious toucans. Most have a red rump and prominent bands on the belly. This species is from northwestern S. America.

»

19 cm
7½ in

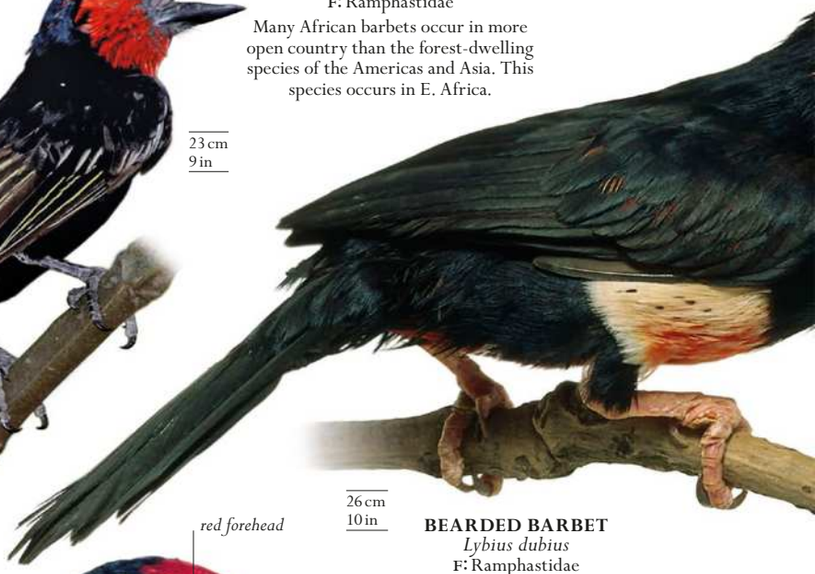
BLACK-SPOTTED BARBET
Capito niger
F: Ramphastidae
This barbet from northern S. America is rarely seen, but its frog-like call is often heard.

17 cm
6½ in

RED-HEADED BARBET
Eubucco bourcierii
F: Ramphastidae
This species is found from Costa Rica to Peru. It is unusual among barbets in being largely silent.

23 cm
9 in

BLACK-BILLED BARBET
Lybius guifsobalito
F: Ramphastidae
Many African barbets occur in more open country than the forest-dwelling species of the Americas and Asia. This species occurs in E. Africa.


26 cm
10 in

BEARDED BARBET
Lybius dubius
F: Ramphastidae
Barbets have sensory bristles at the base of their bill, which are much enlarged in this species from W. and C. Africa.

23 cm
9 in

BLUE-THROATED BARBET
Psilopogon asiaticus
F: Ramphastidae
Asian barbets often forage with other fruit-eaters in the forest canopy. This species occurs from the Himalayas to Thailand.

red forehead
green upperparts
17 cm
6½ in

COPPERSMITH BARBET
Psilopogon haemacephalus
F: Ramphastidae
This is a widespread barbet found in forest edges and scrub. Its incessant "tonk-tonk", hammering call is a common sound in S. Asia.

20 cm
8 in

CRIMSON-FRONTED BARBET
Psilopogon rubricapillus
F: Ramphastidae
A small Asian barbet, this species is restricted to Sri Lanka and southwestern India. It is a common species that is seen in towns.

28 cm
11 in

BROWN-HEADED BARBET
Psilopogon zeylanicus
F: Ramphastidae
A typical Asian barbet, this species from the Himalayas, India, and Sri Lanka is a fruit-eater and especially favours figs.

large, yellowish bill
32–33 cm
12½–13 in
red vent

GREAT BARBET
Psilopogon virens
F: Ramphastidae
The largest Asian barbet, this species is a noisy bird of highland forests from the E. Himalayas to Thailand.

10–11 cm
4–4¼ in

RED-FRONTED TINKERBIRD
Pogoniulus pusillus
F: Ramphastidae
Restricted to riverside forests of the E. African coast, this species feeds on insects and fruits, including mistletoe berries.

tail narrows to point

10–11 cm
4–4¼ in

YELLOW-RUMPED TINKERBIRD
Pogoniulus bilineatus
F: Ramphastidae
Tinkerbirds are small, black and white African barbets with a repetitive call that continues through the day. This species is widespread south of the Sahara.

11 cm
4¼ in

YELLOW-FRONTED TINKERBIRD
Pogoniulus chrysoconus
F: Ramphastidae
A more widespread relative of the red-fronted tinkerbird, this species occurs in dry, open woodland and savanna in sub-Saharan Africa.

RED-FRONTED BARBET
Tricholaema diademata
F: Ramphastidae

An E. African barbet related to the spot-flanked barbet, this species occurs in drier habitats. Like other barbets, it nests in tree-holes.

TOUCAN-BARBET
Semnornis ramphastinus
F: Ramphastidae

A bird of the rainforests of Colombia and Ecuador, this species is intermediate between barbets and toucans. It is exclusively a fruit-eater.

20 cm
8 in

SPOT-FLANKED BARBET
Tricholaema lacrymosa
F: Ramphastidae

A barbet of damp woodlands from C. to E. Africa, the spot-flanked barbet mainly feeds on figs and berries.

D'ARNAUD'S BARBET
Trachyphonus darnaudii
F: Ramphastidae

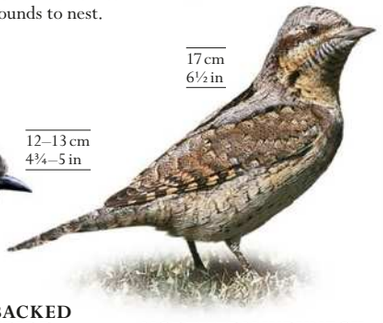
Trachyphonus barbets from Africa live in open country and spend much time on the ground. D'Arnaud's barbet occurs throughout E. Africa.

RED-AND-YELLOW BARBET
Trachyphonus erythrocephalus
F: Ramphastidae

A typical African ground barbet, this bird eats insects, fruits, seeds, and even small lizards. It often burrows into termite mounds to nest.

FIRE-TUFTED BARBET
Psilopogon pyrolophus
F: Ramphastidae

The only Asian barbet with a graduated tail, this S.E. Asian species also has tufts of facial bristles and a cicada-like call.



GREEN-BACKED HONEYBIRD
Prodotiscus zambesiae
F: Indicatoridae

Honeybirds eat insects, fruits, and even beeswax. This African species lays eggs in the nests of the white-eye, a small woodland bird, and its young kill host nestlings.

NORTHERN WRYNECK
Jynx torquilla
F: Picidae

This Eurasian woodland ant-eater has a weaker bill than true woodpeckers and is named for its ability to twist its neck.

BAR-BREASTED PICULET
Picumnus aurifrons
F: Picidae

Piculets are tiny nuthatch-like members of the woodpecker family. They use their short bill for taking insects from decayed wood. This species is from central S. America.

GOLDEN-SPANGLED PICULET
Picumnus exilis
F: Picidae

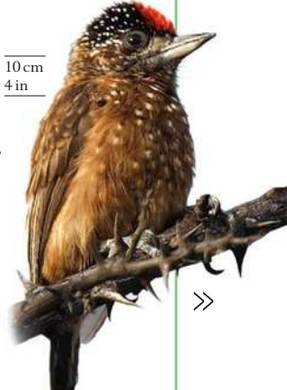
This S. American piculet, like other piculets, lacks stiff, supporting tail feathers of bigger woodpeckers, so it spends less time on vertical trunks.

OCHRACEOUS PICULET
Picumnus limae
F: Picidae

Confined to E. Brazil, the ochraceous piculet – like other piculets – reuses woodpecker nesting holes, as its bill is too small to excavate its own nest.

OCHRE-COLLARED PICULET
Picumnus temminckii
F: Picidae

Confined to the forests of E. Paraguay, S.E. Brazil, and N.E. Argentina, this piculet is well camouflaged by its pattern and coloration.

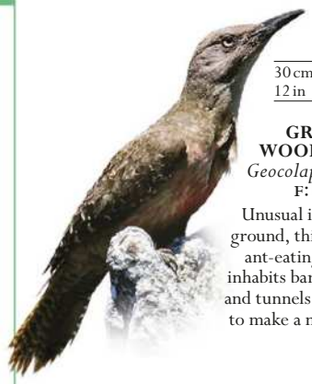


SPOTTED PICULET
Picumnus pygmaeus
F: Picidae

The spotted piculet occurs only in the tropical forests of N.E. Brazil, where it is relatively common.

»

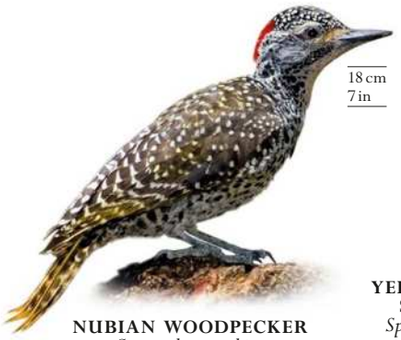
» WOODPECKERS AND TOUCANS



30 cm
12 in

GROUND WOODPECKER
Geocolaptes olivaceus
F: Picidae

Unusual in living on the ground, this South African ant-eating woodpecker inhabits barren, rocky areas and tunnels into earth banks to make a nesting chamber.



18 cm
7 in

NUBIAN WOODPECKER
Campethera nubica
F: Picidae

This relative of the European green woodpecker occurs in dry parts of northeastern Africa, where it is often seen in pairs.

18–22 cm
7–9 in

YELLOW-BELLIED SAPSUCKER
Sphyrapicus varius
F: Picidae

Sapsuckers make holes in trees to drink sap. This fork-tailed species breeds in N. America and migrates to the Caribbean.

28 cm
11 in

COMMON FLAME-BACKED WOODPECKER
Dinopium javanense
F: Picidae

A tropical woodpecker, this species occurs in a variety of woodland types – including mangrove – and ranges from India eastwards to Borneo and Java.

15–17 cm
6–6½ in

HEART-SPOTTED WOODPECKER
Hemicircus canente
F: Picidae

One of two related small, crested woodpeckers from S.E. Asia, this species is named for the black, heart-shaped marks on its back.

45–57 cm
18–22½ in

40–49 cm
16–19½ in

PILEATED WOODPECKER
Dryocopus pileatus
F: Picidae

This is the largest N. American woodpecker. Unlike the Eurasian black woodpecker, American members of the *Dryocopus* genus are crested.

23 cm
9 in

GOLDEN-GREEN WOODPECKER
Piculus chrysochloros
F: Picidae

Typical of a group of green-backed woodpeckers from tropical America, this bird often follows mixed-species flocks, gleaning bark surfaces.

BLACK WOODPECKER
Dryocopus martius
F: Picidae

This large woodpecker from woodlands across N. Eurasia belongs to a small group of predominantly black species that have a red crown.

31–33 cm
12–13 in

GREEN WOODPECKER
Picus viridis
F: Picidae

This European member of a group of Old World green-backed woodpeckers is also called the yaffle after its distinct yelping call.

19–23 cm
7½–9 in

24 cm
9½ in

RED-BELLIED WOODPECKER
Melanerpes carolinus
F: Picidae

Like other *Melanerpes* woodpeckers, this common N. American species stores food in crevices. Despite its name, the belly only has a tinge of red.

RED-HEADED WOODPECKER
Melanerpes erythrocephalus
F: Picidae

A distinctive woodpecker from N. America, this is an aggressive species that destroys nests and eggs of other birds in its territory.

19 cm
7½ in

YELLOW-FRONTED WOODPECKER
Melanerpes flavifrons
F: Picidae

Most *Melanerpes* woodpeckers have partly barred plumage. They may also have striking colours, as does this S. American species.

31 cm
12 in

ROBUST WOODPECKER
Campephilus robustus
F: Picidae

The *Campephilus* woodpeckers are black and white birds with a red head. The robust woodpecker is restricted to eastern S. America.

28–31 cm
11–12 in

NORTHERN FLICKER
Colaptes auratus
F: Picidae

American flickers are so called because of the way their coloured underwings flash in flight. This species has red- and yellow-shafted forms that hybridize.

18–26 cm
7–10 in

HAIRY WOODPECKER
Picoides villosus
F: Picidae

A N. American relative of the three-toed woodpecker, this species becomes more abundant according to the availability of its prey – larvae of bark beetle.

22–23 cm
9 in

GREAT SPOTTED WOODPECKER
Dendrocopos major
F: Picidae

A widespread member of a Eurasian group of pied woodpeckers, this bird is common in forests and gardens from Europe to S.E. Asia.

20–22 cm
8–9 in

MIDDLE-SPOTTED WOODPECKER
Dendrocoptes medius
F: Picidae

A pied woodpecker confined to Europe and S.W. Asia, this species drums less than the related great spotted woodpecker.

18 cm
7 in

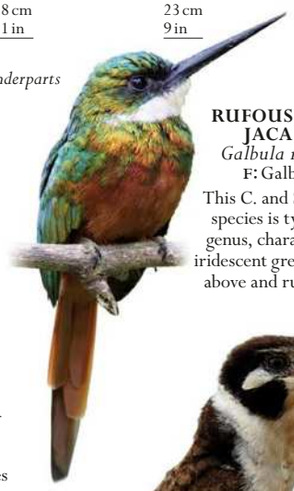
THREE-TOED JACAMAR
Jacamaralcyon tridactyla
F: Galbulidae

The most dull-coloured jacamar, this dry forest species nests in earth banks and has two toes in front and one behind.

28 cm
11 in

GREAT JACAMAR
Jacamerops aureus
F: Galbulidae

This is the largest species of jacamar. It occurs from Costa Rica to Bolivia and feeds mainly on insects, supplemented by small lizards.



23 cm
9 in

RUFOUS-TAILED JACAMAR
Galbula ruficauda
F: Galbulidae

This C. and S. American species is typical of its genus, characterized by iridescent green coloration above and rufous below.

20 cm
8 in

CHESTNUT JACAMAR
Galbalcyrhynchus purusianus
F: Galbulidae

Jacamars specialize in catching large insects, such as butterflies, from the air. This is one of two chestnut-coloured species from S. America.

20–22 cm
8–8½ in

WHITE-EARED PUFFBIRD
Nystalus chacuru
F: Bucconidae

Like other puffbirds, this species from central S. America is a big-headed, "puff-bodied" bird with a heavy bill for catching small animals.

28 cm
11 in

BLACK-FRONTED NUNBIRD
Monasa nigrifrons
F: Bucconidae

Nunbirds are black-bodied relatives of puffbirds. This noisy S. American species often forages beneath monkey troops, feeding on disturbed small animal prey.

14 cm
5½ in

RUSTY-BREASTED NUNLET
Nonnula rubecula
F: Bucconidae

Nunlets are small, drab-coloured members of the puffbird family. This bird is a typical S. American species of vine-bordered forest.

15 cm
6 in

SWALLOW-WINGED PUFFBIRD
Chelidoptera tenebrosa
F: Bucconidae

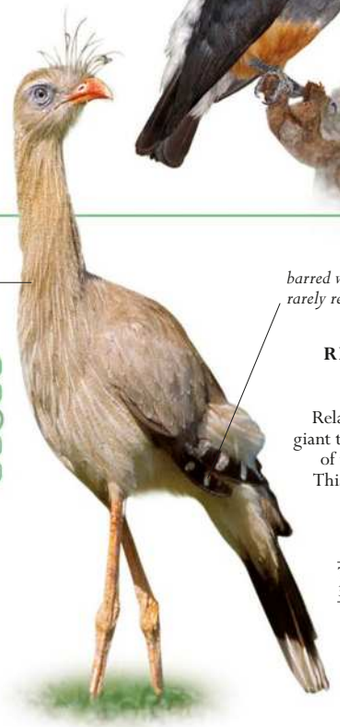
Described as martin-like when perched and bat-like in flight, this bird of northern S. America sallies for flying insects along rivers.

SERIEMAS

Seriemas, order Cariamiformes, are large, long-legged, noisy ground birds of dry savanna woodland in South America, with unclear relationships to other bird orders.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CARIAMIFORMES
FAMILIES	1
SPECIES	2

Once linked with cranes, seriemas have since been placed closer to falcons. The two species are among the largest ground-living birds of South America and rarely fly, except to reach the canopy of trees to nest and roost overnight. Their loud calls make them more often heard than seen.



RED-LEGGED SERIEMA
Cariama cristata
F: Cariamidae

Related to the extinct, predatory, giant terror birds, seriemas are natives of the grasslands of S. America. This species has a sickle-like claw to dismember small prey.

75–90 cm
30–35 in

PASSERINES

This huge order makes up around 60 per cent of all bird species. They are known collectively as perching birds, for their specialized feet.

Like many birds, passerines have four-toed feet with three toes pointing forwards and one back. As a passerine lands, a muscle automatically tightens tendons running through the legs so that the toes lock around a perch, securing the bird even in sleep.

These birds, of the order Passeriformes, are found in almost all land habitats worldwide, from dense rainforest to arid desert and even freezing Arctic tundra. They range in size from the tiny American flycatchers, no bigger than hummingbirds, to the powerfully built Eurasian ravens.

DIVERSITY

The order includes birds adapted to a variety of feeding habits. The insect-eaters have a bill like a needle for probing foliage or with a wide gape for catching prey in flight. Other passerines have a stubby bill for cracking open seeds, while some have a long curved bill for extracting nectar.

Passerines combine a high metabolic rate with a comparatively large brain size, giving some the resilience to tolerate cold and a few the intelligence to master the use of simple tools. They produce helpless, naked young, which are reared in nests ranging from simple cups to elaborate mud-chambers or hanging purses of woven grass. A few passerines are brood parasites, laying their eggs in the nests of other species.

SONGBIRDS

Passerines are split into two groups, largely on the basis of the structure of their vocal box. The first group, the Suboscines, forms around a fifth of all passerines. It occurs in the Old World tropics but has greatest diversity in America; it includes broadbills, pittas, antbirds, and tyrant flycatchers. The second group, the Oscines, includes all remaining passerine families, popularly known as songbirds. Birds often communicate by voice, but the structure of their vocal box enables many passerines to deliver complex songs that are important in courtship and defending territory. Songs are often so distinctive that they can be used to identify species.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PASSERIFORMES
FAMILIES	141
SPECIES	6,456

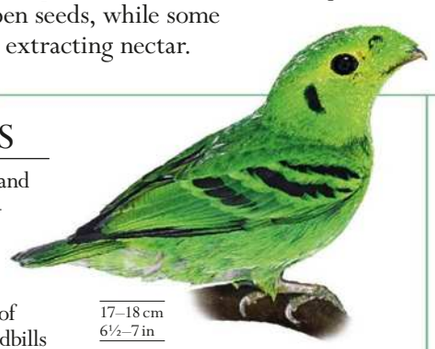
DEBATE

OUT OF AUSTRALIA

Early DNA analysis identified two songbird groups: Corvida and Passerida. The mostly Old World Corvida includes carnivores and fruit-eaters, such as crows and birds of paradise. The global Passerida – with more than a quarter of all bird species – includes tits, sunbirds, and finches. Later techniques revealed several primitive Australian groups, such as the lyrebirds, which do not belong to either of these divisions. Together with fossil evidence, this suggests that songbirds diversified in Australasia before giving rise to Corvida and Passerida.

BROADBILLS

The families Calyptomenidae and Eurylaimidae consist of forest-dwelling birds from tropical Africa and Asia. They mostly use their wide bill to catch insects in trees, but members of one group of Asian green broadbills are fruit-eaters.



17–18 cm
6½–7 in

GREEN BROADBILL
Calyptomena viridis
One of the three S.E. Asian green broadbills, this bird is a specialist fruit-eater and builds globular hanging nests.

BLACK-AND-RED BROADBILL
Cymbirhynchus macrorhynchos
This distinctively coloured S.E. Asian broadbill frequents forests near water. It builds a pouch-like nest suspended from the tips of branches.

BLACK-AND-YELLOW BROADBILL
Eurylaimus ochromalus
An Asian insect-eating broadbill, this species forages in the middle and upper levels of rainforests from Myanmar to Borneo and Sumatra.

ASITIES

The brush-tipped tongue of these Madagascan birds, the Philepittidae, suggests that they may have evolved from nectar-feeding ancestors: one genus is now fruit-eating; the other resembles the unrelated sunbirds that feed on nectar.

COMMON SUNBIRD-ASITY
Neodrepanis coruscans
One of two long-billed birds from eastern Madagascar, this species evolved the nectar-feeding habit of true sunbirds, but is unrelated to them.

PITTAS

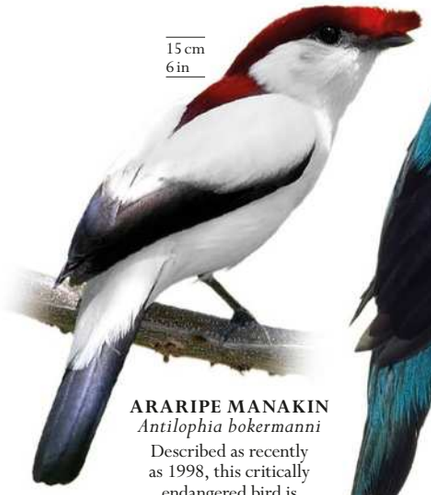
Birds of this Old World family forage for insects on the forest floor in tropical regions. The Pittidae have a rounded body and a short bill, and many species are brilliantly plumaged. Both adults incubate the eggs.

BLUE-WINGED PITTA
Pitta moluccensis
Found from S. China to Borneo and Sumatra, the blue-winged pitta inhabits dense forest when breeding, but overwinters in coastal scrub.

INDIAN PITTA
Pitta brachyura
Like its relatives, this pitta from the S. Himalayas, India, and Sri Lanka builds domed nests on or near the ground.

MANAKINS

These birds, the Pipridae, are related to cotingas. The brightly coloured males gather in groups called leks to display to females. For many species, courtship involves elaborate dancing movements. Females build the nest and rear offspring alone.

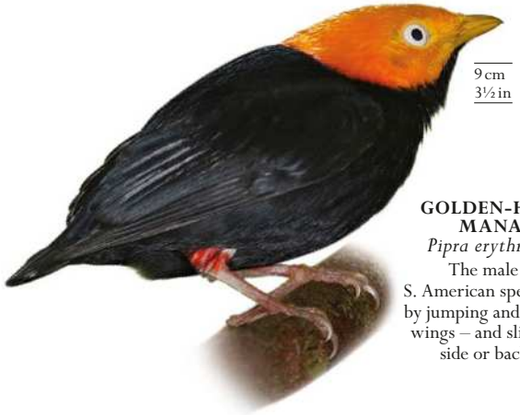


ARARIPE MANAKIN
Antilophia bokermanni
Described as recently as 1998, this critically endangered bird is found only in the Araripe highlands of N.E. Brazil.

BLUE MANAKIN
Chiroxiphia caudata
One of the most colourful birds of the rainforest of S. Brazil, the blue manakin has a whining, cat-like call.

PIN-TAILED MANAKIN
Ilicura militaris
Males of this manakin from S.E. Brazil have elongated central tail feathers and display to females with raised rump feathers.

STRIPED MANAKIN
Machaeropterus regulus
This is an inconspicuous species of northern S. America. Males of the species have been observed making insect-like buzzing sounds while displaying.

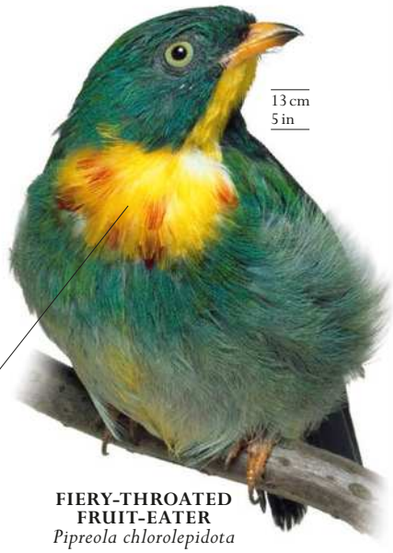


GOLDEN-HEADED MANAKIN
Pipra erythrocephala
The male of this S. American species displays by jumping and whirring its wings – and sliding to one side or backwards.

COTINGAS AND RELATIVES

A diverse group of tropical American passerines, the Cotingidae consists of fruit-eating or insect-eating forest birds.

Males are brightly coloured and are highly vocal when courting females; some species display in trees and others on the ground.



FIERY-THROATED FRUIT-EATER
Pipreola chlorolepidota
Fruit-eaters are stocky green birds, males of which are usually black headed and red or yellow throated. This is a small Andean species.

BARE-THROATED BELLBIRD
Procnias nudicollis
Bellbirds are named after their metallic calls. Like other bellbirds, males of this eastern S. American species have white plumage.

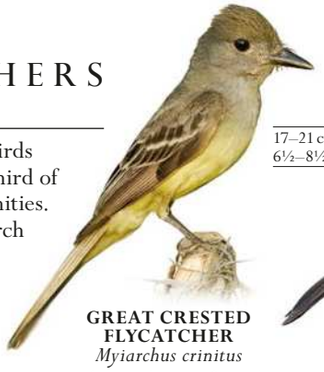
PURPLE-THROATED FRUITCROW
Querula purpurata
Males of this distinctive Amazonian cotinga have a prominent, iridescent purplish red throat patch. It can pluck fruits while hovering in mid-air.

BLACK-TAILED TITYRA
Tityra cayana
This canopy bird belongs to a group of big-headed fruit-eaters. It nests in tree-holes, often those abandoned by woodpeckers.

ANDEAN COCK-OF-THE-ROCK
Rupicola peruvianus
The colourful crested males of this large Andean cotinga display in groups to females. Females nest among rocks and rear young alone.

TYRANT FLYCATCHERS AND RELATIVES

Widespread throughout the Americas, these birds of the family Tyrannidae often account for a third of all passerines in South American bird communities. These birds are insectivorous and typically perch and wait for prey or glean it from foliage.

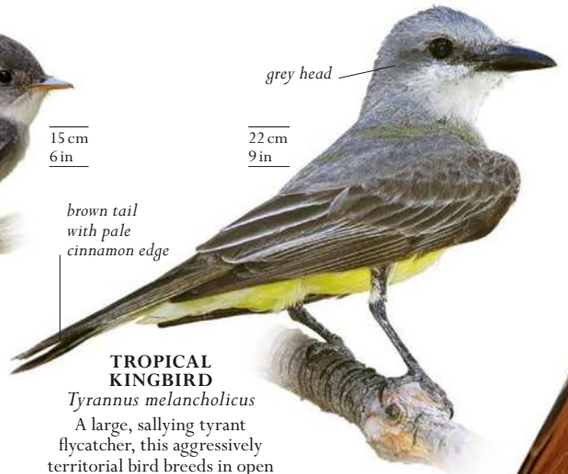


17–21 cm
6½–8½ in

GREAT CRESTED FLYCATCHER
Myiarchus crinitus
A widespread tyrant flycatcher, this large, migratory species, like its relatives, catches insects on the wing. It often hovers when foraging.

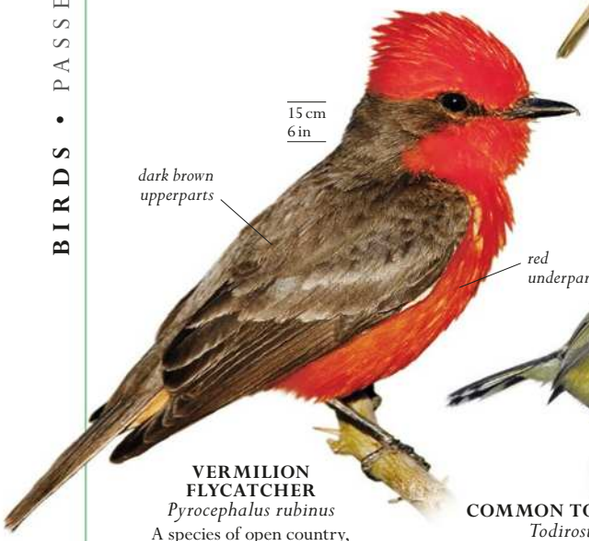
15 cm
6 in

EASTERN WOOD PEWEE
Contopus virens
This bird, with its characteristic "pewee" call, hunts by sallying – taking off from perches to catch insects in mid-air. It breeds in eastern N. America.



22 cm
9 in

TROPICAL KINGBIRD
Tyrannus melancholicus
A large, sallying tyrant flycatcher, this aggressively territorial bird breeds in open habitats from southern N. America to S. America.



15 cm
6 in

VERMILION FLYCATCHER
Pyrocephalus rubinus
A species of open country, this bird forages near the ground. Males are vivid red, whereas females are mainly grey and white.

10 cm
4 in

COMMON TODY-FLYCATCHER
Todirostrum cinereum
This tiny C. and S. American tyrant flycatcher is typical of a group that forages by upward striking, but favours more open habitat than its relatives.

19 cm
7½ in

CLIFF FLYCATCHER
Hirundinea ferruginea
This flycatcher from northern and central S. America is swallow-like in its aerial foraging behaviour, and perches on rocky outcrops.

17 cm
6½ in

BLACK PHOEBE
Sayornis nigricans
This tail-wagging, tyrant flycatcher forages close to the ground in tropical regions, often near water. It dives into ponds to capture minnows.

TYPICAL ANTBIRDS

From tropical American forests, these heavy-billed birds of the family Thamnophilidae hunt insects near the ground, with some following army ants to feed on insects fleeing the ants. Some are long-clawed for gripping vertical stems.

18 cm
7 in

WHITE-BEARDED ANTSHRIKE
Biatus nigropectus
This little-known, uncommon species is restricted to S.E. Brazil, where it feeds on insects in bamboo forests. It is threatened by deforestation.

ANTPITTAS AND ANT-THRUSHES

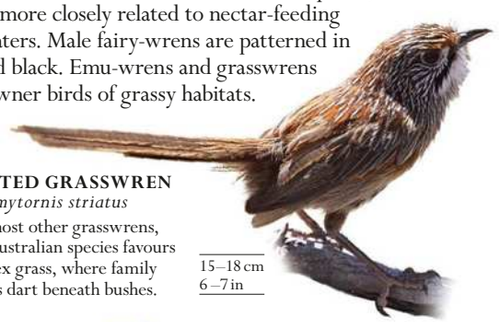
Short-tailed antpittas spend more time on the ground than the tree-dwelling ant-thrushes. Both are insectivores of South American forests and belong to the families Grallariidae and Formicariidae, respectively.

18 cm
7 in

MOUSTACHED ANTPITTA
Grallaria alleni
A rare species found in isolated localities in Colombia and Ecuador, the moustached antpitta inhabits undergrowth in humid montane forest.

AUSTRALASIAN WRENS

The Maluridae are small, cock-tailed insect-eaters that resemble wrens of the northern hemisphere, but are more closely related to nectar-feeding honeyeaters. Male fairy-wrens are patterned in blue and black. Emu-wrens and grasswrens are browner birds of grassy habitats.



STRIATED GRASSWREN
Amytornis striatus
Like most other grasswrens, this C. Australian species favours spinifex grass, where family groups dart beneath bushes.

15–18 cm
6–7 in

15 cm
6 in

VARIEGATED FAIRY-WREN
Malurus lamberti
This most widespread Australian fairy-wren, like others, builds a domed nest. Young may stay close to help raise the next brood.

SPLENDID FAIRY-WREN
Malurus splendens
Fairy-wrens form strong pair bonds, but partners may mate with other individuals. This species is found mostly in southern Australia.

14 cm
5½ in

TAPACULOS AND CRESCENT-CHESTS

Strong-legged and weak-flying, the Rhinocryptidae and Melanopareiidae, are among the most ground adapted of South American passerines. Some have long hind claws to scratch for food in soil and leaf litter.

14–15 cm
5½–6 in

COLLARED CRESCENT-CHEST
Melanopareia torquata
Crescent-chests have a longer tail than tapaculos and have been separated into a new family, the Melanopareiidae. This Brazilian species occurs in arid habitats.

GNATEATERS

Dumpy, short-tailed, long-legged insect-eaters of forest undergrowth, gnateaters of the family Conophagidae are secretive birds that forage near the ground using tyrant-like sallying or gleaning techniques. They are related to antbirds.

13 cm
5 in

RUFOUS GNATEATER
Conopophaga lineata
More abundant than other gnateater species, this bird from eastern S. America often moves in mixed-species flocks and uses degraded habitats.

BOWERBIRDS AND CATBIRDS

The Australasian family Ptilonorhynchidae consists predominantly of fruit-eaters. Male bowerbirds – often brightly coloured – build structures called bowers to attract females. They mate with many females and play no part in raising the young.

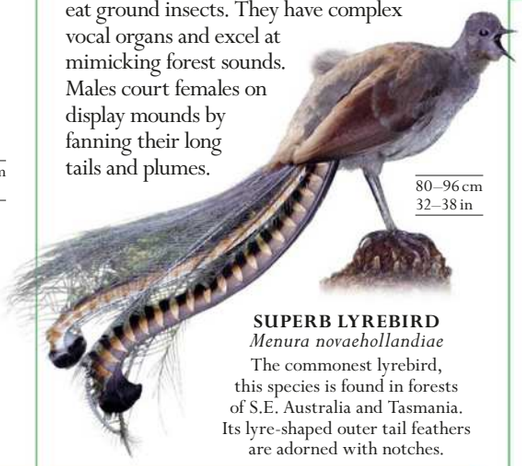
GREAT KISKADEE
Pitangus sulphuratus
Widespread through tropical America and named after its call, this species is a typical sallying tyrant flycatcher, but also forages near the ground.

GREEN CATBIRD
Ailuroedus crassirostris
Male catbirds – named for their cat-like call – attract mates by laying leaves on the ground. This species is found in New Guinea and E. Australia.

GOLDEN BOWERBIRD
Prionodura newtoniana
The male of this small species from N. Australia attracts a mate by building a tower of sticks up to 3 m (10 ft) high.

LYREBIRDS

The Menuridae are large Australian birds that eat ground insects. They have complex vocal organs and excel at mimicking forest sounds. Males court females on display mounds by fanning their long tails and plumes.



SUPERB LYREBIRD
Menura novaehollandiae
The commonest lyrebird, this species is found in forests of S.E. Australia and Tasmania. Its lyre-shaped outer tail feathers are adorned with notches.

AUSTRALASIAN TREECREEPERS

The birds of the family Climacteridae have evolved to resemble the northern treecreepers, but are unrelated and, unlike them, do not use their tail for support when climbing up trees.

BROWN TREECREEPER
Climacteris picumnus
This common eastern Australian species has a distinct dark-backed form in the north of the range and a brown-backed form in the south.

OVENBIRDS AND RELATIVES

These American birds, the Furnariidae, are adept at hunting hidden invertebrates and are known for the immense diversity of their nest architecture. This includes stick nests, tunnel nests, and those that resemble clay ovens.

WHITE-EYED FOLIAGE-GLEANER
Automolus leucophthalmus
A S. American bird with distinctive white irises, like many insect-eaters, this species forages in mixed flocks to flush out prey.

RUFOUS HORNERO
Furnarius rufus
Widespread in central and southern S. America, this species, typical of the hornero group, builds an oven-like mud nest.

HONEYEATERS

The birds of the family Meliphagidae are from Australia and the southwest Pacific islands. They feed on nectar with a long, brush-tipped tongue and are important pollinators of plants in that region. Other nectar-feeders, such as sunbirds, have evolved similar features.

SCARLET HONEYEATER
Myzomela sanguinolenta
This bird is an E. Australian member of a group of long-billed, flower-visiting honeyeaters that often carry daubs of pollen on their forehead.

BLUE-FACED HONEYEATER
Entomyzon cyanotis
A large, noisy honeyeater from Australia and New Guinea, this species is more insectivorous than many others, but it also feeds on fruits.

LEWIN'S HONEYEATER
Meliphaga lewinii
A member of a short-billed group of honeyeaters, this species from eastern Australia eats insects, fruits, and berries.

EASTERN SPINEBILL
Acanthorhynchus tenuirostris
Spinebills are an ancient group of heathland honeyeaters and the most specialized nectar-feeders of the family. This species is from E. Australia.

TUI
Prosthemadera novaeseelandiae
Although confined to New Zealand, this species is related to short-billed honeyeaters of Australia. It has an extraordinary vocal range.

NEW HOLLAND HONEYEATER
Phylidonyris novaehollandiae
Like other honeyeaters, this white-whiskered species from southern Australia and Tasmania also takes honeydew – the waste sugar solution produced by certain sap-sucking insects.

WOODCREEPERS

The tropical American birds of the family Dendrocolaptidae are specialists at climbing up tree trunks. They have stiffened tails for support and strongly clawed front toes for gripping the bark.

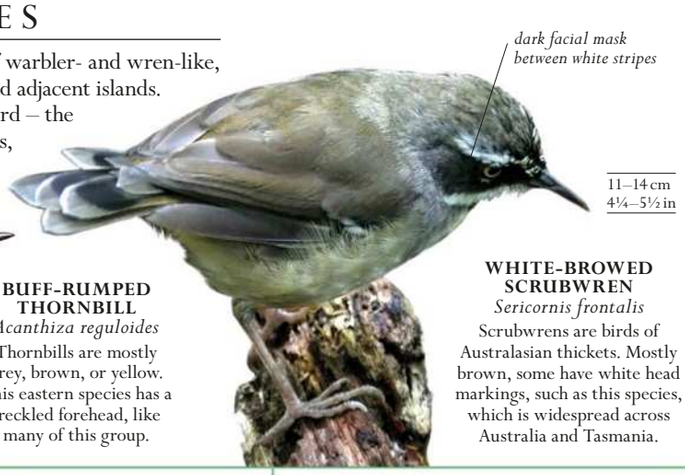
SCALLOPED WOODCREEPER
Lepidocolaptes falcinellus
This typical buff and brown woodcreeper is found only in the forests of southeastern S. America.

THORNBILLS AND RELATIVES

The Acanthizidae is a small family of warbler- and wren-like, insect-eating birds from Australia and adjacent islands. It also includes Australia's smallest bird – the weebill. These birds have short wings, a short tail, and drab-coloured, longish legs.

11 cm
4¼ in

BUFF-RUMPED THORNBILL
Acanthiza reguloides
Thornbills are mostly grey, brown, or yellow. This eastern species has a freckled forehead, like many of this group.



11–14 cm
4¼–5½ in

WHITE-BROWED SCRUBWREN
Sericornis frontalis
Scrubwrens are birds of Australasian thickets. Mostly brown, some have white head markings, such as this species, which is widespread across Australia and Tasmania.

PARDALOTES

Dumpy birds from Australia, the Pardalotidae have a stubby bill for gleaning sap-sucking scale insects from trees. Brightly coloured, they nest in deep tunnels in earth banks.

8–10 cm
3¼–4 in

SPOTTED PARDALOTE
Pardalotus punctatus
Three of the four species of pardalotes have white spots. This highly active bird is from dry forests in S. and E. Australia.

WOODSWALLOWS, BUTCHERBIRDS, AND RELATIVES

From Southeast Asia, New Guinea, and Australasia, the birds in the family Artamidae include woodswallows that catch insects in flight and are among the few small passerines that can soar. The Australasian butcherbirds, currawongs, and ground-dwelling Australian magpies are intelligent, highly vocal, omnivorous birds.

19 cm
7½ in

MASKED WOODSWALLOW
Artamus personatus
This dark-faced, thick-billed woodswallow occurs in drier parts of inland Australia and is highly nomadic. Like other woodswallows, it often gathers in large flocks.

34–44 cm
13½–17½ in

AUSTRALIAN MAGPIE
Gymnorhina tibicen
A widespread Australian species with a highly variable black and white plumage, this bird has a varied and melodious song and is a capable mimic.

IORAS

These rainforest birds, the Aegithinidae, are usually active in the high canopy. Their green or yellow coloration camouflages them in foliage, where they glean for insects. Males can engage in elaborate courtship displays.

15 cm
6 in

COMMON IORA
Aegithina tiphia
The smallest and most widespread iora, it is found across tropical Asia, from India to Borneo, sometimes in disturbed habitats. This bird builds a cup-shaped nest.

CROWS AND JAYS

The family Corvidae, occurring worldwide, includes some of the biggest passerines. They are intelligent, opportunistic birds that have complex social organization and strong pair-bonding. Crows have demonstrated tool use, play behaviour, and perhaps even self-awareness.

33–39 cm
13–15½ in

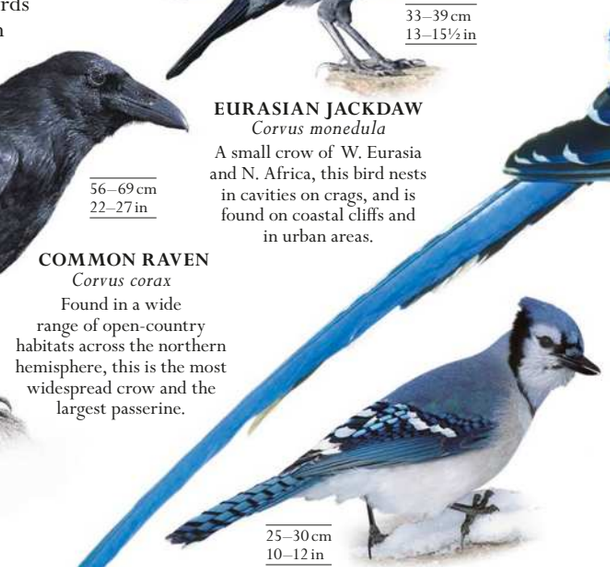
EURASIAN JACKDAW
Corvus monedula
A small crow of W. Eurasia and N. Africa, this bird nests in cavities on crags, and is found on coastal cliffs and in urban areas.

56–69 cm
22–27 in

COMMON RAVEN
Corvus corax
Found in a wide range of open-country habitats across the northern hemisphere, this is the most widespread crow and the largest passerine.

46–50 cm
18–20 in

PIED CROW
Corvus albus
A relative of the raven, this heavy-billed bird of open country is perhaps the commonest member of the crow family in Africa and Madagascar.



25–30 cm
10–12 in

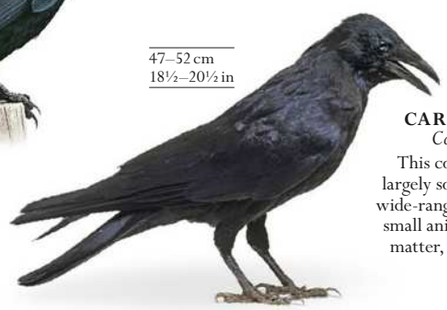
BLUE JAY
Cyanocitta cristata
This colourful jay of N. America lives in tightly bonded family groups. It is fond of acorns and disperses them, helping to distribute oak trees.

46 cm
18 in

COMMON MAGPIE
Pica pica
This Eurasian bird is common in habitats ranging from open woodland to semi-desert. It is related more closely to *Corvus* crows than Asian magpies.

45–48 cm
18–19 in

ROOK
Corvus frugilegus
Routinely flocking throughout the year in Eurasia, this bare-faced crow nests in colonies in trees in open countryside.



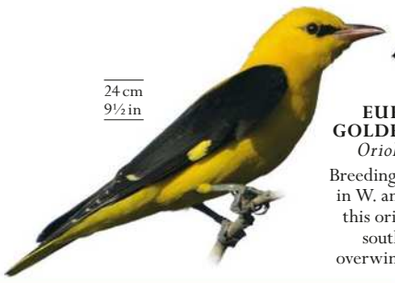
47–52 cm
18½–20½ in

CARRION CROW
Corvus corone
This common Eurasian, largely solitary species has a wide-ranging diet. It feeds on small animals and vegetable matter, as well as carrion.

ORIOLES

Old World passerines related to shrikes and crows, the birds of the family Oriolidae live in forest canopies and eat insects and fruits. Many species have striking yellow and black plumage. The females are usually greener than males.

27–29 cm
10½–11½ in



24 cm
9½ in

EURASIAN GOLDEN ORIOLE
Oriolus oriolus
Breeding in woodlands in W. and C. Eurasia, this oriole migrates southwards to overwinter in Africa.

AUSTRALASIAN FIGBIRD
Sphecotheres vieilloti
Stout-billed relatives of orioles from Australasia, figbirds are gregarious fruit-eaters. This species occurs in N. and E. Australia.

SHRIKES

The family Laniidae contains predators of open country. Many species store their prey (insects and small vertebrates) by impaling them on thorns. Most occur in Africa and Eurasia; two species live in North America.

17–18 cm
6½–7 in

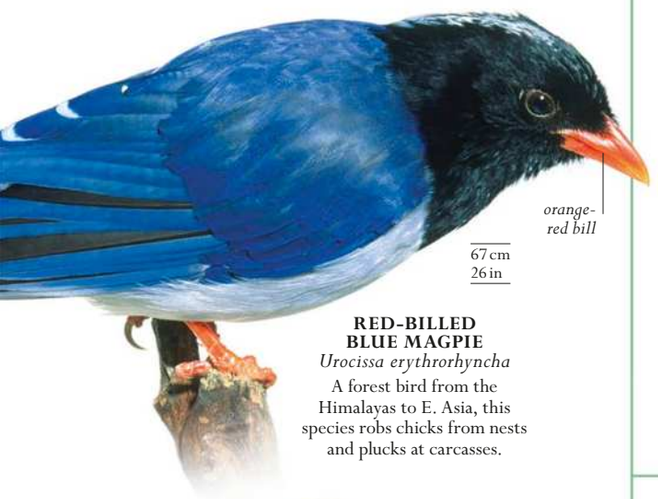
RED-BACKED SHRIKE
Lanius collurio
This bird breeds from Europe to Siberia and overwinters in Africa. Like other *Lanius* shrikes, it has a musical call.

BUSH-SHRIKES AND RELATIVES

The family Malaconotidae is entirely confined to Africa. They are found mostly in scrubby, open woodland, and have a hooked bill for catching large insects.

CRIMSON-BREASTED GONOLEK
Laniarius atrococcineus
Members of the African bush-shrike family, gonoleks have red and black plumage. This species occurs in southern Africa.

23 cm
9 in



67 cm
26 in

RED-BILLED BLUE MAGPIE
Urocissa erythrorhyncha
A forest bird from the Himalayas to E. Asia, this species robs chicks from nests and plucks at carcasses.

DRONGOS

Black, long-tailed birds of Old World tropics, the Dicruridae sally for insects, bolting out suddenly to catch their prey. They are aggressive birds, and sometimes attack larger species to defend their nests.

26 cm
10 in

CRESTED DRONGO
Dicrurus forficatus
Like other drongos, this Madagascan species has a long, forked tail and red eyes. It has a distinctive tuft of feathers at the base of its bill.

WATTLE-EYES AND RELATIVES

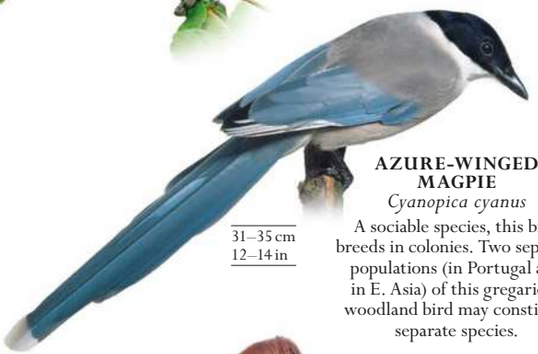
The Platysteiridae, wattle-eyes and their relatives, form a family of insect-eating birds from Africa. They have a flat, hooked bill with bristles at the base. Like flycatchers, they snatch their prey suddenly.

13 cm
5 in

BROWN-THROATED WATTLE-EYE
Platysteira cyanea
Wattle-eyes get their name from the red skin around their eyes. This common species occurs in woodland throughout sub-Saharan Africa.

29 cm
11½ in

GREEN JAY
Cyanocorax yncas
This bird feeds on fruits and seeds. S. American populations of the green jay differ sufficiently from those of C. America to be considered as separate species.



31–35 cm
12–14 in

AZURE-WINGED MAGPIE
Cyanopica cyanus
A sociable species, this bird breeds in colonies. Two separate populations (in Portugal and in E. Asia) of this gregarious woodland bird may constitute separate species.

34 cm
13½ in

EURASIAN JAY
Garrulus glandarius
More closely related to Old World crows than American jays, this colourful woodland bird habitually hoards acorns in autumn.

VANGAS AND RELATIVES

The predatory passerines of the family Vangidae include the helmet-shrikes of Africa and vangas from Madagascar. They feed on invertebrates, reptiles, and frogs, and have a range of bill shapes – chisel-, sickle-, and dagger-shaped – for different prey and feeding techniques.

20 cm
8 in

WHITE HELMET-SHRIKE
Prionops plumatus
Widespread across sub-Saharan Africa, the white-crested helmet-shrike often gathers in small groups. This bird has a wide range of different calls.

20 cm
8 in

RUFOUS VANGA
Schetba rufa
Common in the forests of Madagascar, this bird resembles a shrike, but is not closely related to the shrike family.

VIREOS

Superficially resembling American warblers, but somewhat thicker-billed, the members of the family Vireonidae are more closely related to crows, and Old World orioles and shrikes. They take insects by gleaning or fly catching, and also eat some fruits.

11 cm
4¼ in

BLACK-CAPPED VIREO
Vireo atricapilla
This species breeds in N. America and migrates to Mexico. Unlike other vireos, the sexes differ. The male is black-capped, while the female is grey-capped.

12–13 cm
4¾–5 in

RED-EYED VIREO
Vireo olivaceus
N. American populations of this very vocal vireo migrate to S. America, where they join resident races of the same species.

TYPICAL TITS

These small, acrobatic, usually hole-nesting birds of the family Paridae occur in wooded habitats across North America, Eurasia, and Africa. They frequently hang upside down to glean insects from foliage, and manipulate seeds and nuts to crack them open.

14–16 cm
5½–6½ in

12–14 cm
4¾–5½ in

VARIED TIT
Sittaparus varius

This species is found in forest habitats, including conifers and bamboo forests, in N.E. Asia, Japan, and Taiwan.

12–15 cm
4¾–6 in

BLACK-CAPPED CHICKADEE
Poecile atricapillus

A typically inquisitive and acrobatic tit, this is a common N. American bird. Like other tits, it hoards seeds for later use.

TUFTED TITMOUSE
Baeolophus bicolor

Like other tits, this eastern N. American species supplements its insect diet with seeds, holding them firmly to smash them with its bill.

14 cm
5½ in

GREAT TIT
Parus major

Widespread across Eurasia, this tit occurs in habitats from forest to heathland, and has a diverse range of vocalization.

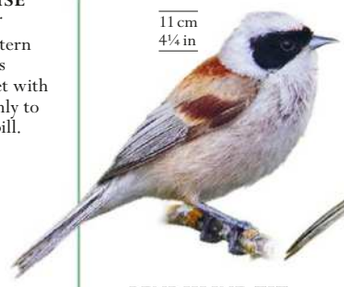
11–12 cm
4½–4¾ in

BLUE TIT
Cyanistes caeruleus

This common bird of broadleaf woodlands in Europe, Turkey, and N. Africa is a frequent visitor to bird feeders in gardens.

PENDULINE TITS

These small, needle-billed birds from the family Remizidae occur in Africa and Eurasia, with one species in America. Most use cobwebs and other soft material to build flask-shaped nests that hang from branches, often over water.



11 cm
4¼ in

9–11 cm
3½–4¼ in

PENDULINE TIT
Remiz pendulinus

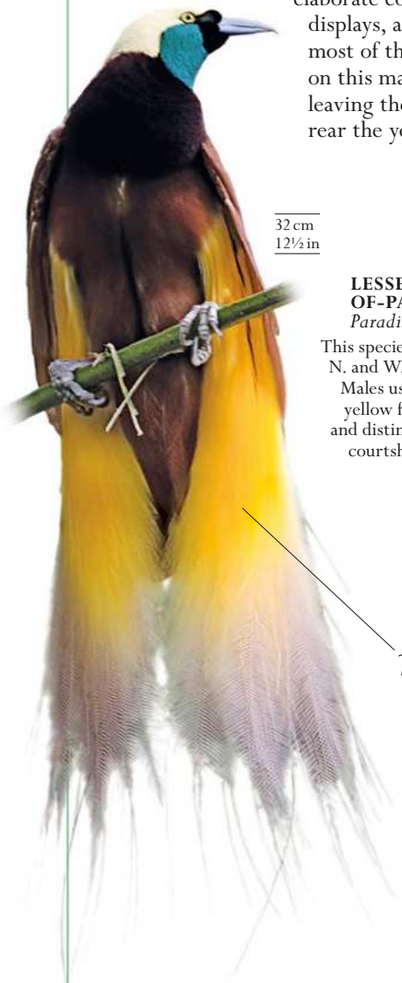
The only member of the family to have a wide range across Eurasia, this species occurs on marshes with trees, where it builds its pendulous nest.

VERDIN
Auriparus flaviceps

Unlike most other penduline tits, the verdin makes a spherical nest. It is found in desert scrub of the S. USA and Mexico.

BIRDS-OF-PARADISE

Mainly found in the rainforests of New Guinea, members of the family Paradisaeidae are mostly fruit-eating birds. The males display their bright, gaudy plumes in elaborate courtship displays, and spend most of their energy on this mating ritual, leaving the females to rear the young alone.



32 cm
12½ in

LESSER BIRD-OF-PARADISE
Paradisaea minor

This species occurs across N. and W. New Guinea. Males use their long, yellow flank plumes and distinctive cape for courtship displays.

yellow flank plumes

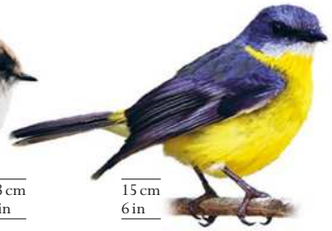
AUSTRALIAN ROBINS

The Petroicidae are chunky, round-headed insect-eaters. Unrelated to the robins of Europe or America, they are found from Australasia to the islands of the southwest Pacific. Some exhibit co-operative breeding, in which young birds help their parents to raise a new brood.

13 cm
5 in

JACKY WINTER
Microeca fascinans

This common robin uses its broad bill for fly-catching. It is widespread in woodland throughout Australia and New Guinea.



15 cm
6 in

EASTERN YELLOW ROBIN
Eopsaltria australis

Common in the woodlands and gardens of E. Australia, this bird sallies from low perches for invertebrates, which it snatches from the ground.

WAXWINGS

From the family Bombycillidae, these berry-eating birds are named for the waxy, red-tipped shafts on their wings. Three species occur in the cool northern forests of North America and Eurasia.

18 cm
7 in

BOHEMIAN WAXWING
Bombycilla garrulus

This sleek bird is pinkish brown, with chestnut undertail feathers. It breeds in northern taiga forest and is attracted to berried shrubs during its migration south.

LONG-TAILED TITS

Birds of the family Aegithalidae are small, restless insect-eaters that build dome-shaped nests that are woven with cobwebs and lined with feathers. Most species are found in Eurasia, with one occurring in North America.

14 cm
5½ in

LONG-TAILED TIT
Aegithalos caudatus

The most widespread long-tailed tit, this woodland bird inhabits a range from N. to C. Eurasia, gathering in restless flocks when not breeding.

SILKY FLYCATCHERS

The family Ptilogonatidae from Central America has just four species. These birds are named for their soft plumage (similar to that of related waxwings) and their feeding habits.

18–21 cm
7–8½ in

PHAINOPEPLA
Phainopepla nitens

This bird of the S. USA and Mexico nests colonially in woodland, but is territorial when breeding in deserts.

MONARCHS AND RELATIVES

Generally long-tailed birds, members of the Monarchidae have a broad bill for fly-catching. Most species occur in Old World tropical forests. With the exception of the magpie-lark, they are tree-dwellers that build cup-shaped nests decorated with lichen.

AFRICAN PARADISE-FLYCATCHER
Terpsiphone viridis
This bird has variable colour forms, but all males have long tail streamers. This species occurs in savanna, south of the Sahara.

MAGPIE-LARK
Grallina cyanoleuca
Unlike other members of the monarch family, this Australian bird spends much time on the ground and builds a large mud nest.

AUSTRALIAN MUDNESTERS

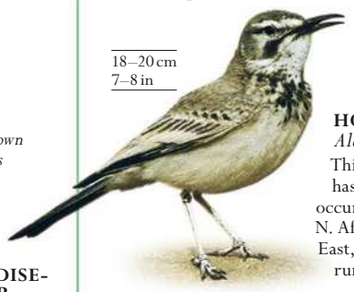
The family Corcoracidae contains two species of social birds that feed on the ground and build large, cup-shaped nests of grass. These are held together with mud and are made in trees on horizontal branches.

APOSTLEBIRD
Struthidea cinerea
This ground-living bird associates in flocks of 6 to 20 individuals. It occurs in woodlands of northern and E. Australia.

LARKS

Brown in colour, with a melodious call, these birds from the family Alaudidae inhabit arid, open habitats. Most occur in Africa, with one species in North America. They usually have long hind claws that provide the stability they need to spend so much time on the ground.

HORNED LARK
Eremophila alpestris
This lark breeds on Arctic N. American and Eurasian tundra. It overwinters on coastlines further south.



GREATER HOOPOE-LARK
Alaemon alaudipes
This long-legged lark has a curved bill and occurs in arid habitats of N. Africa and the Middle East, where it habitually runs on the ground.

EURASIAN SKYLARK
Alauda arvensis
Common across Eurasia, from the British Isles to Japan, this open-country bird is notable for its musical aerial song.

BULBULS

Found across the warmer parts of Eurasia and Africa, most bulbuls of the family Pycnonotidae are gregarious, noisy, fruit-eating birds. The soft plumage of many species is drably coloured, marked by red or yellow feathers beneath the tail.

BLACK BULBUL
Hypsipetes leucocephalus
Common in forests and gardens in India, China, and Thailand, this species exists in dark-headed and white-headed races.

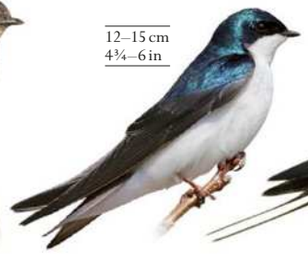
RED-WHISKERED BULBUL
Pycnonotus jocosus
A common Asian bulbul found from India to the Malay Peninsula, this is an opportunistic woodland species that is also found near villages.

SWALLOWS AND MARTINS

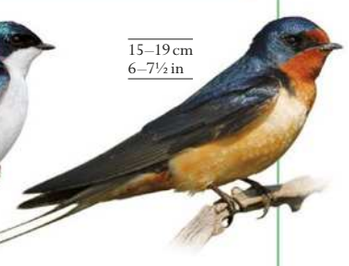
From the family Hirundinidae, these swift-like birds have long wings and a forked tail. Their short, flattened bill and wide gape help in taking insects on the wing. They build mud nests or use tree-holes or tunnels in banks.

GREATER STRIPED SWALLOW
Cecropis cucullata
This African grassland swallow breeds towards the south of the continent and migrates northwards to overwinter.

COLLARED SAND MARTIN
Riparia riparia
Like other swallows, this species migrates south to overwinter in the tropics. It nests in colonies in riverside banks across the northern hemisphere.



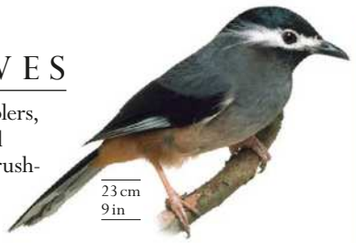
TREE SWALLOW
Tachycineta bicolor
This N. American swallow of wooded swamps supplements its insect diet with berries. This enables it to breed further north than other swallows.



BARN SWALLOW
Hirundo rustica
Occurring worldwide, this is the most widespread species of swallow. It was originally a cave-nester, but now uses buildings as well.

BABBLERS, LAUGHING THRUSHES, AND RELATIVES

Generally more gregarious, noisier, and less migratory than warblers, the babblers and laughing thrushes of the families Timaliidae and Leiothrichidae have evolved into a variety of warbler-like and thrush-like forms. Some species are brightly coloured.



WHITE-EARED SIBIA
Heterophasia auricularis
Sibias are nectar-feeding babblers. This species is confined to Taiwan, where its distinctive call is often heard in mountain forests.

CHESTNUT-CAPPED BABBLER
Timalia pileata
A bird of low thickets in S.E. Asia, this babbler is often found near water, along with flycatchers and other babblers.

SILVER-EARED MESIA
Leiothrix argentauris
A skulking, montane forest bird, this S.E. Asian species belongs to a group of "song babblers", which includes minlas, sibias, and laughing thrushes.

RED-TAILED MINLA
Minla ignotincta
This small babbler is similar to a tit. It is a noisy inhabitant of montane forest canopies in Nepal, China, and Myanmar.

GREATER NECKLACED LAUGHING-THRUSH
Garrulax pectoralis
Laughing thrushes are large forest babblers with laughing calls. They often move in mixed flocks. This species inhabits the Himalayas and S.E. Asia.

GNATCATCHERS

These small American insect-eaters from the family Polioptilidae are related to wrens, but are more warbler-like in appearance. In common with several members of the wren family, some gnatcatchers cock their tail when foraging.

BLUE-GREY GNATCATCHER
Polioptila caerulea
This N. American gnatcatcher may flick its white-edged tail to flush insects. Unlike related gnatcatcher species, males do not have dark head markings.

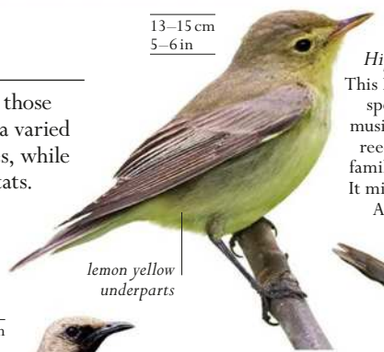
TREECREEPERS

From the family Certhiidae, these are small insect-eating birds of the northern hemisphere. They forage on vertical tree trunks using their tail as a prop, habitually climbing one tree and flying to the bottom of the next.

EURASIAN TREECREEPER
Certhia familiaris
This is the most widespread *Certhia* treecreeper. It is found across Eurasia, from Britain to Japan, in broadleaf and coniferous forests.

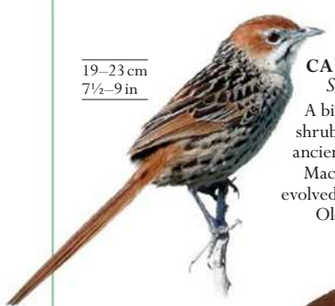
OLD WORLD WARBLERS AND RELATIVES

Several families, such as the large and widespread Sylviidae and those with fewer species such as Madagascar's Bernieridae, comprise a varied group of thin-billed, insectivorous birds. Some are forest species, while others inhabit low bushes, dense grasses, or taller reedbed habitats. Many are subtly patterned and difficult to tell apart.



ICTERINE WARBLER
Hippolais icterina
This Eurasian woodland species has a more musical call than other reed warblers of the family Acrocephalidae. It migrates to southern Africa in winter.

SEDGE WARBLER
Acrocephalus schoenobaenus
This is one of many species of reed warblers (inhabitants of wetland areas) that breeds in Eurasia and winters in Africa.



CAPE GRASSBIRD
Sphenoeacus afer
A bird of South African shrubland,it belongs to an ancient African family, the Macrosphenidae, which evolved separately from other Old World warblers.

BROWN SONGLARK
Cincloramphus cruralis
This "grassbird" warbler from Australia in the family Locustellidae is a nomad of open habitats. Like larks, it sallies skywards from exposed perches.

WRENTIT
Chamaea fasciata
A dull-coloured bird with a cocked tail, the wrentit is the only New World member of the family Sylviidae. It may be related to parrotbills.

VINOUS-THROATED PARROTBILL
Sinosuthura webbiana
Despite its stumpy seed-cracking bill, this long-tailed Asian parrotbill is a member of the insectivorous Old World warblers family Sylviidae. This species occurs in China and Korea.

BLACKCAP
Sylvia atricapilla
Male *Sylvia* warblers are typically patterned with patches of black or brown. In this widespread Eurasian species, females have a brown cap.

SUBALPINE WARBLER
Sylvia cantillans
Like many *Sylvia* warblers, this species breeds in scrubby Mediterranean habitats and winters in Africa.

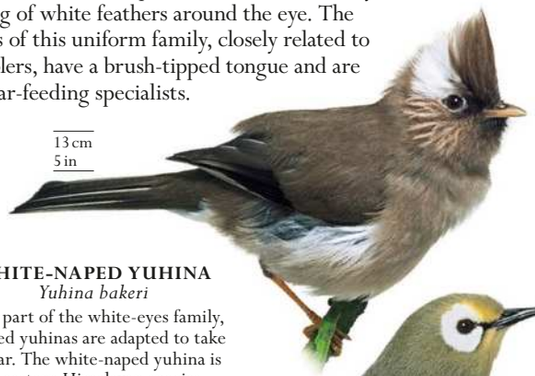
BEARDED TIT

The Bearded Tit forms a single-species family, the Panuridae. A reedbed specialist, it eats insects in summer and hardens its stomach in winter to digest reed seeds.

BEARDED TIT
Panurus biarmicus

WHITE-EYES

Most of the Zosteropidae are characterized by a ring of white feathers around the eye. The birds of this uniform family, closely related to babblers, have a brush-tipped tongue and are nectar-feeding specialists.



WHITE-NAPED YUHINA
Yuhina bakeri
Now part of the white-eyes family, crested yuhinas are adapted to take nectar. The white-naped yuhina is an eastern Himalayan species.

BROAD-RINGED WHITE-EYE
Zosterops poliogastrus
This open woodland white-eye is restricted to isolated mountain ranges in Ethiopia, Kenya, and Tanzania. Distinct races are found according to region.

FAIRY-BLUEBIRDS

Two species of fairy-bluebirds, from the family Irenidae, are found in Southeast Asia, where they feed on fruits – especially figs – in forest canopies. Only males have a vivid blue colour; females are dull green.

ASIAN FAIRY-BLUEBIRD
Irena puella
The most widespread fairy-bluebird, found from India to Indonesia, this species often feeds with other fruit-eaters, such as hornbills and pigeons.

GOLDCRESTS

Among the smallest of passerines, these colour-crested birds of the family Regulidae are found in cool northern forests. They have a high metabolic rate, which forces them to feed constantly when awake. They glean tiny, soft-bodied invertebrates from foliage with their needle-like bill.

GOLDCREST
Regulus regulus
All kinglets are adapted to coniferous forests. The Eurasian goldcrest has especially grooved feet and enlarged toe-pads for clinging to needle-like leaves.

RUBY-CROWNED KINGLET
Regulus calendula
The red head patch of this N. American species is visible when it raises its crown feathers – a trait shared by all kinglets.

NUTHATCHES AND RELATIVES

Nuthatches, in the family Sittidae, and the wallcreeper, sole member of the family Tichodromidae, are more acrobatic than treecreepers, and do not use their tail as a support. They feed on seeds as well as insects, sometimes hoarding them in crevices.

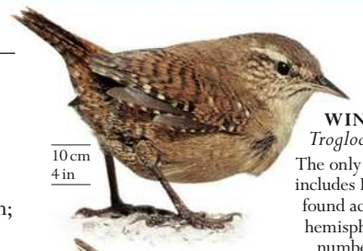
WALLCREEPER
Tichodroma muraria
This central Eurasian mountain bird gleans insects from rocks with its pointed bill.

EURASIAN NUTHATCH
Sitta europaea
A widespread species, this forest bird can – like other nuthatches – crack open nuts by wedging them in cracks in tree bark.

RED-BREASTED NUTHATCH
Sitta canadensis
This N. American species has a similar body pattern to the Eurasian species, but males are more vividly coloured.

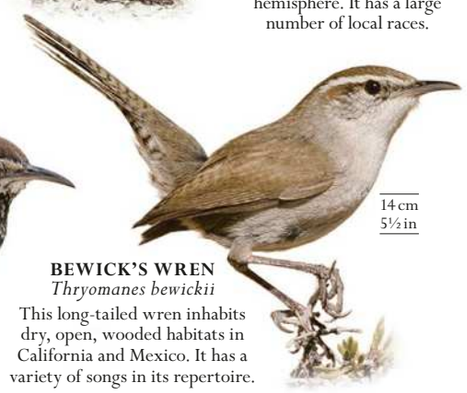
WRENS

With the exception of the winter wren, the family Troglodytidae is confined to the Americas. Most species are highly vocal, but visually inconspicuous, short-winged birds that forage on insects in undergrowth; some even sleep on the ground.



WINTER WREN
Troglodytes troglodytes
The only wren whose range includes Eurasia, this bird is found across the northern hemisphere. It has a large number of local races.

CACTUS WREN
Campylorhynchus brunneicapillus
The largest wren, this species occurs in deserts of California and Mexico, where it forages in groups on the ground.



BEWICK'S WREN
Thryomanes bewickii
This long-tailed wren inhabits dry, open, wooded habitats in California and Mexico. It has a variety of songs in its repertoire.

MOCKINGBIRDS AND RELATIVES

Birds of the family Mimidae occur throughout much of the Americas, and the Caribbean and Galapagos Islands. Usually grey or brown, these strong-legged birds are highly vocal; some are accomplished mimics.

CURVE-BILLED THRASHER
Toxostoma curvirostre
A bird of arid, scrubby habitats in the S. USA and Mexico, this species uses its long bill to probe the soil for invertebrates.

27 cm
10½ in

21–26 cm
8½–10 in

NORTHERN MOCKINGBIRD
Mimus polyglottos
This N. American bird is famous for its extraordinary repertoire of varied songs, which it delivers day and night.

21–24 cm
8½–9½ in

GREY CATBIRD
Dumetella carolinensis
Named for its cat-like mewing call, this N. American bird forages on the ground. It overwinters in C. America and the Caribbean.

STARLINGS AND MYNAS

From the family Sturnidae, these are mostly gregarious, noisy birds, many with a glossy plumage that has a metallic sheen. This family is divided into mynas and relatives from southern Asia and the Pacific, and true starlings from Africa and Eurasia.

27–31 cm
10½–12 in

HILL MYNA
Gracula religiosa
Found in forests of tropical Asia, this species is a popular cage bird. It is notable for its melodious call and its mimicking ability.

50 cm
20 in

WHITE-NECKED MYNA
Streptocitta albicollis
This long-tailed, magpie-like myna is restricted to rainforests in Sulawesi, Indonesia, and adjacent islands, where it usually associates in pairs.

25 cm
10 in

BALI MYNA
Leucopsar rothschildi
Found only in the rainforests of Bali, Indonesia, this striking bird is highly endangered by habitat destruction and the bird trade.

OXPECKERS

In the family Buphagidae, oxpeckers bound low over African savannas in undulating flight. Although their strong feet provide a tight grip on the hide of large animals as the birds feed, their short legs are unsuitable for walking on the ground.

YELLOW-BILLED OXPECKER
Buphagus africanus
Common in savanna across sub-Saharan Africa, this bird habitually perches on large mammals, eating parasites but also pecking at wounds.

19–22 cm
7½–9 in

OLD WORLD FLYCATCHERS AND CHATS

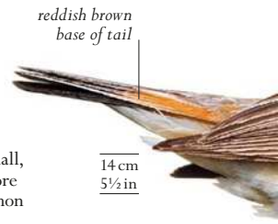
Related to thrushes, the family Muscicapidae is divided into two groups: true flycatchers, with a broad bill for snatching flying insects; and chats, which include robins, nightingales, and wheatears. Some species are brightly coloured, but most of these small birds have predominantly grey or brown plumage.

18 cm
7 in

BLUE-AND-WHITE FLYCATCHER
Cyanoptila cyanomelaena
Belonging to a large group of vivid blue flycatchers from tropical Asia, this species from E. Asia forages high in forests.

13 cm
5 in

COMMON STONECHAT
Saxicola torquatus
Typical of chats, this is a small, upright, perching insectivore with a harsh call. It is common in grassland in Eurasia and Africa.



14 cm
5½ in

14 cm
5½ in

EUROPEAN ROBIN
Erithacus rubecula
Related to chats, this bird of hedgerows and woodland is found in W. Eurasia and N. Africa. In Britain, it is a common garden visitor.

15–16 cm
6–6½ in

NORTHERN WHEATEAR
Oenanthe oenanthe
Wheatears are white-rumped chats of open country. This is the most widespread species across Eurasia. It winters in Africa.

19–21 cm
7½–8½ in

MOCKING CLIFFCHAT
Thamnolaea cinnamomeiventris
Belonging to a group of dark-coloured African chats, this bird occurs in bushy, rocky habitats and can become tame near villages.

13–14 cm
5–5½ in

WHITE-BROWED SHORTWING
Brachypteryx montana
Now members of the flycatchers family, shortwings are running birds found in Asian forests. This species occurs from the Himalayas to Java, Indonesia.

14 cm
5½ in

COMMON REDSTART
Phoenicurus phoenicurus
Named for the reddish brown tail, redstarts are chat-like birds found mainly in Asia. This species occurs from W. to C. Eurasia and migrates to E. Africa.

THRUSHES AND RELATIVES

Belonging to the family Turdidae, most thrushes are woodland birds that forage on the ground for invertebrate prey, such as earthworms, snails, and insects. They are found worldwide, but the majority of species occur in the Old World. Many have melodious songs.

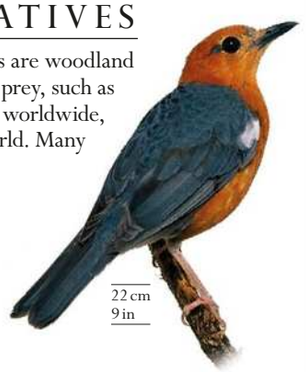
EUROPEAN STARLING
Sturnus vulgaris
Native to Eurasia, but introduced to N. America, this common starling roosts communally, in groups that gather after mass aerial manoeuvres.

SPLENDID GLOSSY STARLING
Lamprotornis splendidus
Widespread in sub-Saharan Africa, this species belongs to a group of African starlings characterized by a metallic sheen on their plumage.

HILDEBRANDT'S STARLING
Lamprotornis hildebrandti
This E. African glossy starling occurs in wooded savanna, where it preys on large ground insects, often flocking with other starling species.

EMERALD STARLING
Lamprotornis iris
This glossy W. African species feeds mainly on fruits, especially figs, but also takes ants.

EASTERN BLUEBIRD
Sialia sialis
A bird of eastern N. America, this is a common species of open woodland and fields. It sometimes nests in old woodpecker holes.



ORANGE-HEADED THRUSH
Zoothera citrina
One of many tropical Old World *Zoothera* thrushes, this species is found in forests from the Himalayas to Bali, Indonesia.

VARIED THRUSH
Ixoreus naevius
Found in mature coniferous forests of western N. America, this bird overwinters in parks and gardens. Like other thrushes, it forages in ground litter.

19–26 cm
7½–10 in

BLUETHROAT
Luscinia svecica
A relative of the nightingale, the bluethroat breeds in damp regions of N. Eurasia, and migrates to Africa and S.E. Asia.

WHITE-TAILED ROBIN
Myiomela leucura
A bird of riverine forests from the Himalayas to Indochina, it usually keeps close to the ground unless disturbed.

SONG THRUSH
Turdus philomelos
Found from Europe to Siberia, this woodland and garden bird habitually uses a hard surface as an "anvil" to smash open snail shells.

AMERICAN ROBIN
Turdus migratorius
Unrelated to the European robin, this N. American thrush sometimes gathers in winter roosts of up to quarter of a million birds.

PIED FLYCATCHER
Ficedula hypoleuca
This large genus of mainly Asian flycatchers is closely related to chats. This woodland species ranges from Europe to Siberia.

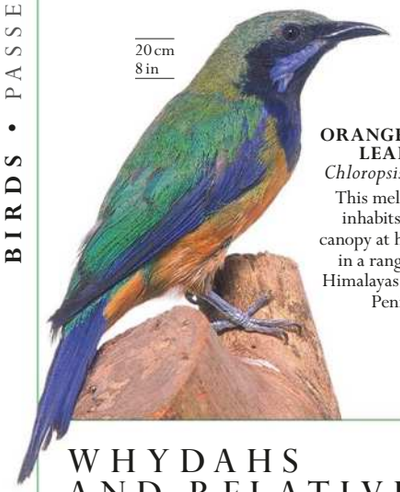
EURASIAN BLACKBIRD
Turdus merula
A common long-tailed thrush of woodland habitats ranging from Europe and N. Africa to India, the highly territorial blackbird often visits gardens.

FIELDFARE
Turdus pilaris
This bird breeds in N. Eurasia and winters further south, where it flocks together in fields.

COMMON NIGHTINGALE
Luscinia megarhynchos
This brown bird of W. to C. Eurasian thickets is known for its loud, rich song, which it sings night or day.

LEAFBIRDS

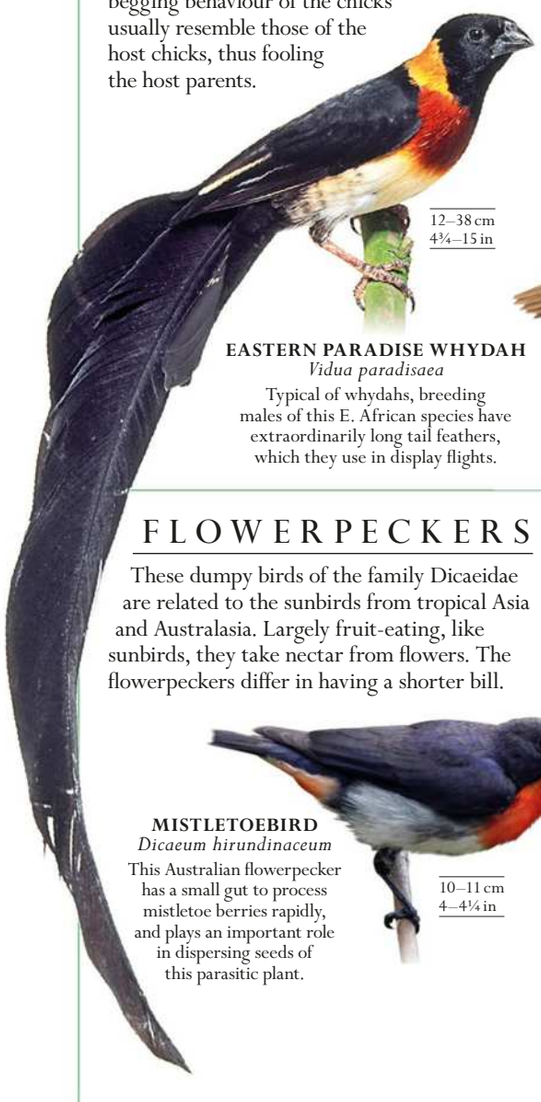
The fruit-eating birds of the family Chloropseidae occur in forests in southeastern Asia. They use their brush-tipped tongue to take nectar, with which they supplement their diet. Male leafbirds are characteristically green, with a blue or black throat.



ORANGE-BELLIED LEAFBIRD
Chloropsis hardwickei
This melodious bird inhabits the forest canopy at high altitudes, in a range from the Himalayas to the Malay Peninsula.

WHYDAHS AND RELATIVES

African whydah birds and related indigobirds of the family Viduidae are cuckoo-like brood parasites of waxbills. The mouthparts and begging behaviour of the chicks usually resemble those of the host chicks, thus fooling the host parents.



EASTERN PARADISE WHYDAH
Vidua paradisaea
Typical of whydahs, breeding males of this E. African species have extraordinarily long tail feathers, which they use in display flights.

WAXBILLS AND RELATIVES

Consisting of small, highly gregarious, often brightly coloured seed-eaters, the family Estrildidae occurs in tropical Africa, Asia, and Australia. Many birds live in grassland or open woodland and build dome-like nests. Both parents share parental duties.

ZEBRA FINCH
Taeniopygia guttata
Native to the drier parts of Australia, the zebra finch is a popular cagebird around the world.

JAVA SPARROW
Lonchura oryzivora
This vulnerable species from Java and Bali frequents farmland and feeds on cereal crops. It has been hunted as a rice pest and for the pet trade.

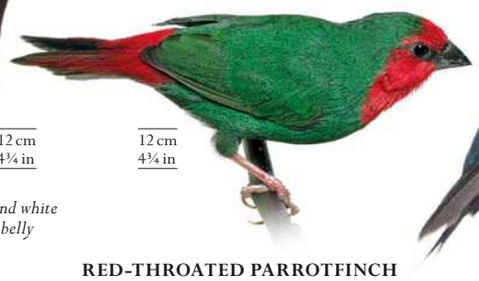
PURPLE GRENADIER
Uraeginthus ianthinogaster
An E. African bird of dry woodland, the purple grenadier belongs to a genus of predominantly blue waxbills.

COMMON WAXBILL
Estrilda astrild
Abundant throughout Africa, this tiny waxbill, like related species, is a restless, flocking bird of open land, feeding on grass seeds.

GREEN-WINGED PYTILIA
Pytilia melba
Male *Pytilia* waxbills have red splashes on their wings. This African species is host to the paradise whydah (*Vidua paradisaea*), a brood parasite.

GREEN-BACK TWINSPOT
Mandingoa nitidula
Found in western to southern Africa, this thicket-dwelling twinspot has white-spotted underparts and is more secretive than other waxbills.

SCALY-BREASTED MUNIA
Lonchura punctulata
This bird is common in S. Asian scrub. Male and female are alike in appearance.



RED-THROATED PARROTFINCH
Erythrura psittacea
Parrotfinches are mostly green-bodied waxbills from S.E. Asia to the Pacific Ocean. This species occurs in grasslands of the island of New Caledonia.

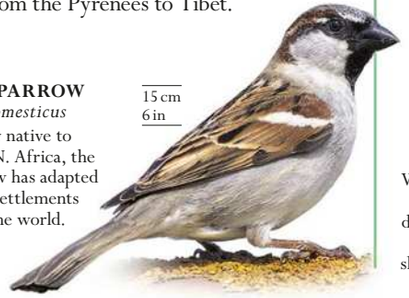
FLOWERPECKERS

These dumpy birds of the family Dicaeidae are related to the sunbirds from tropical Asia and Australasia. Largely fruit-eating, like sunbirds, they take nectar from flowers. The flowerpeckers differ in having a shorter bill.

MISTLETOEBIRD
Dicaeum hirundinaceum
This Australian flowerpecker has a small gut to process mistletoe berries rapidly, and plays an important role in dispersing seeds of this parasitic plant.

OLD WORLD SPARROWS

These stubby-billed, seed-eating birds, the Passeridae, are found across Africa and Eurasia. As well as the familiar true sparrows, the group includes snowfinches, mountain-dwelling birds that occur from the Pyrenees to Tibet.

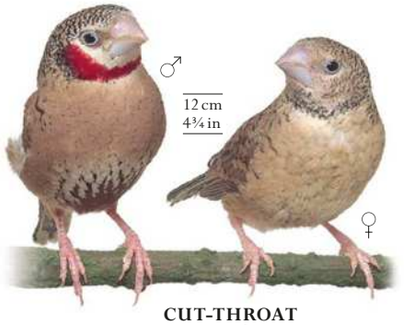


HOUSE SPARROW
Passer domesticus
Originally native to Eurasia and N. Africa, the house sparrow has adapted to human settlements around the world.

DIPPERS

Belonging to the family Cinclidae, dippers are the only passerines that can dive and swim under water. They have adaptations for their aquatic lifestyle, such as well-oiled, waterproof feathers and oxygen-storing blood.

WHITE-THROATED DIPPER
Cinclus cinclus
Widespread through temperate Eurasia, the white-throated dipper breeds near fast-flowing streams but may move to slower-flowing rivers in winter.

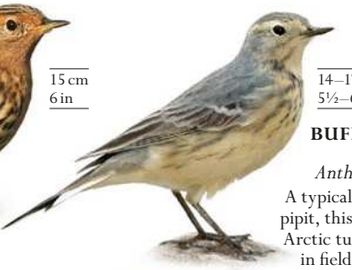


CUT-THROAT
Amadina fasciata
Named for the male's red neck patch, this is a common bird of dry African woodlands, and is often found near human habitations.

PIPITS AND WAGTAILS

Present on every continent, the birds of the family Motacillidae inhabit open country, where they feed on insects. Most wagtails have longer tails and are more brightly coloured than more sombre pipits, and some are associated with water.

RED-THROATED PIPIT
Anthus cervinus
This pipit breeds in Arctic tundra, during which it develops a coloured throat: reddish brown in males and pink in females.

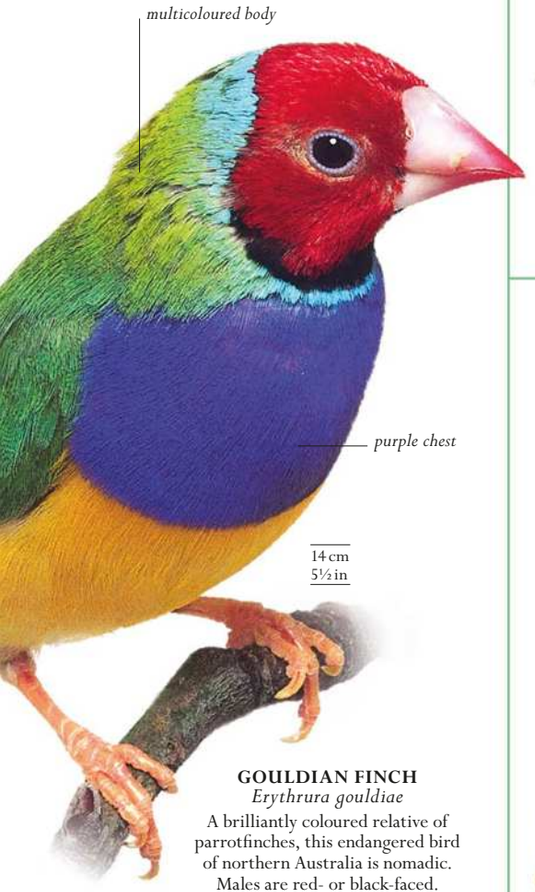


BUFF-BELLIED PIPIT
Anthus rubescens
A typical ground-running pipit, this species breeds in Arctic tundra and winters in fields and on coasts further south.

GOLDEN PIPIT
Tmetothylacus tenellus
A bird of open bush and grassland, the golden pipit is confined to E. Africa, from Sudan to Tanzania.

YELLOW WAGTAIL
Motacilla flava
This widespread Eurasian species overwinters in Africa, India, and Australia. There are many races, including many with grey or black head patterns.

WHITE WAGTAIL
Motacilla alba
A typical wagtail, this species is widespread throughout Eurasia – often on farmland or in towns.

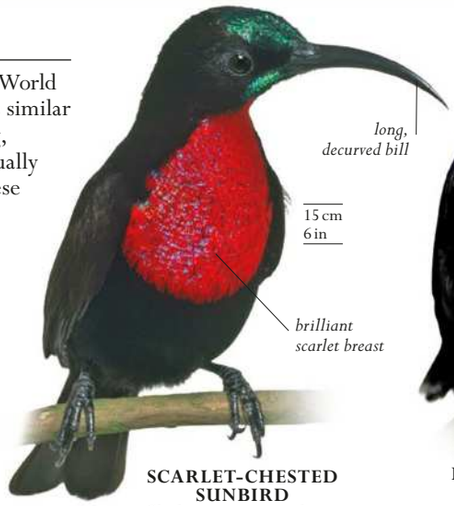


GOULDIAN FINCH
Erythrura gouldiae
A brilliantly coloured relative of parrotfinches, this endangered bird of northern Australia is nomadic. Males are red- or black-faced.

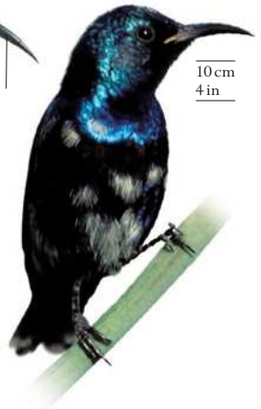
SUNBIRDS

The small, fast-moving, nectar-feeding Old World tropical birds of the family Nectarinidae are similar to American hummingbirds, with their long, decurved bill and long tongue. Males are usually brightly coloured with a metallic sheen. These birds are fiercely territorial.

STREAKY-BREASTED SPIDERHUNTER
Arachnothera affinis
Spiderhunters are drab, long-billed members of the sunbird family. Like other sunbirds, this S.E. Asian species eats invertebrates as well as nectar.



SCARLET-CHESTED SUNBIRD
Chalcomitra senegalensis
Common throughout much of sub-Saharan Africa, this large sunbird occupies a variety of wooded habitats.



PURPLE SUNBIRD
Cinnyris asiaticus
Like other sunbirds, this species from S. Asia feeds its young mostly on insects. The male loses its brilliant plumage after breeding.

WEAVERS

Gregarious seed-eaters, the Ploceidae build elaborate nests. Males usually take sole responsibility for this duty; females use the nest as the basis for choosing mates. Most species are African, with a few found in southern Asia.

CHESTNUT WEAVER
Ploceus rubiginosus
The genus *Ploceus* includes the largest number of species of weavers. This species occurs in E. Africa.

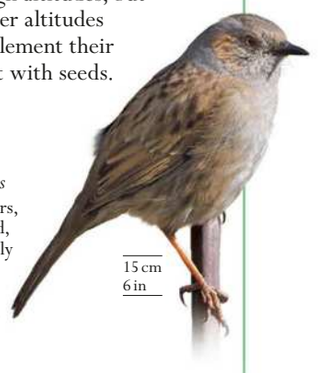
RED-BILLED QUELEA
Quelea quelea
Widely considered the world's most abundant bird, this African species gathers in giant flocks that can cause serious damage to crops.

RED-COLLARED WIDOWBIRD
Euplectes ardens
Breeding males of widowbirds are black and some fan enlarged tails during display flights. This species is widespread in sub-Saharan Africa.

YELLOW-CROWNED BISHOP
Euplectes afer
This African bird is related to widowbirds. Breeding males are vibrantly patterned; females and non-breeding males are red or black.

ACCENTORS

Mostly ground-dwelling passerines, the narrow-billed Prunellidae are found in Eurasia. Most species are adapted to high altitudes, but they move to lower altitudes in winter to supplement their insectivorous diet with seeds.



DUNNOCK
Prunella modularis
Unlike other accentors, this is a lowland bird, and it does not usually gather in flocks. It is widespread in temperate Eurasia.

FINCHES AND RELATIVES

Finches of the family Fringillidae have diversified in Eurasia, Africa, and the tropical regions of the Americas. From thin-billed nectar-feeders to heavy-billed, seed-cracking grosbeaks and hawfinches, these birds have evolved to cope with a wide range of foods.

12 cm
4¾ in

EURASIAN GOLDFINCH
Carduelis carduelis
Goldfinches have a thinly pointed bill for taking seeds from the seed heads of tall plants, such as thistles. This species is widespread in Eurasia.

12–13 cm
4¾–5 in

AMERICAN GOLDFINCH
Carduelis tristis
Bright yellow goldfinches and siskins have diversified in the Americas, especially in S. America. This migratory species is from N. America.

15 cm
6 in

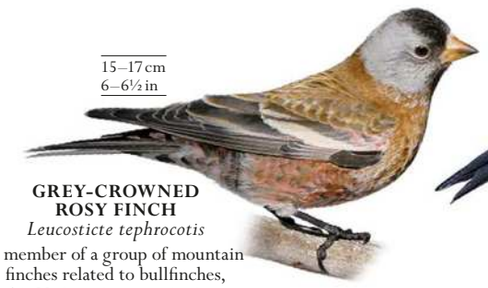
CHAFFINCH
Fringilla coelebs
The commonest finch in Europe, the chaffinch is also found throughout N. Asia. It often forages with other finch species in winter.

17 cm
6½ in

RED CROSSBILL
Loxia curvirostra
Crossbills use their uniquely crossed mandibles for extracting seeds from cones. This species is widespread in coniferous forests across the northern hemisphere.

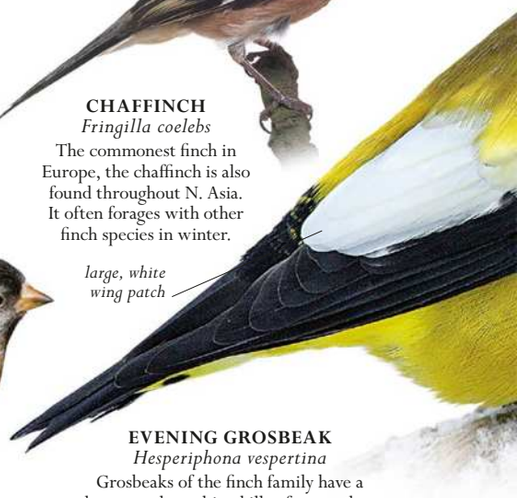
12 cm
4¾ in

YELLOW-FRONTED CANARY
Serinus mozambicus
This bird belongs to a group of mostly yellow-coloured African serins and canaries. It is common south of the Sahara.



15–17 cm
6–6½ in

GREY-CROWNED ROSY FINCH
Leucosticte tephrocotis
A member of a group of mountain finches related to bullfinches, this N. American species is an inhabitant of high, rocky landscapes.



EVENING GROSBEAK
Hesperiphona vespertina
Grosbeaks of the finch family have a heavy seed-crushing bill, a feature they share with the unrelated grosbeaks of the cardinal-grosbeak family. This is a N. American species.

AMERICAN BLACKBIRDS AND RELATIVES

These American species of the family Icteridae superficially resemble the common blackbird, to which they are not related. As a group, these strong-billed birds are more closely related to finches. The bill has a powerful gaping action for prising apart tough food.

21–26 cm
8½–10 in

YELLOW-HEADED BLACKBIRD
Xanthocephalus xanthocephalus
This marshland bird of western N. America breeds in colonies and sites its nests over water, perhaps to deter predators.

17–24 cm
6½–9½ in

RED-WINGED BLACKBIRD
Agelaius phoeniceus
A N. American bird of marshy habitats, this colonial nester often breeds in the company of the larger, more dominant, yellow-headed blackbird.

19–26 cm
7½–10 in

EASTERN MEADOWLARK
Sturnella magna
A species from eastern N. America, this open-country bird builds a nest on the ground, covering it with a grass roof.

28–34 cm
11–13½ in

COMMON GRACKLE
Quiscalus quiscula
An opportunistic N. American species, this bird raids refuse dumps and corn crops. Its internally keeled bill can saw open acorns.

19–22 cm
7½–9 in

BROWN-HEADED COWBIRD
Molothrus ater
This N. American bird produces many eggs, laying them in the nests of other passerines. Its young are raised by many different host species.

18–20 cm
7–8 in

BALTIMORE ORIOLE
Icterus galbula
Feeding on insects and caterpillars in spring and summer, this species changes its diet in winter to include nectar and berries.

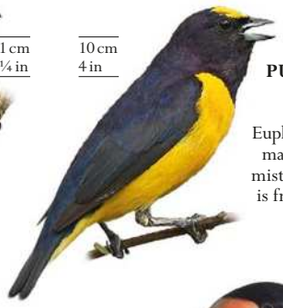
15–20 cm
6–8 in

BOBOLINK
Dolichonyx oryzivorus
This ground-nesting N. American bird gets its name from its bubbling flight song. It migrates to central S. America in winter.

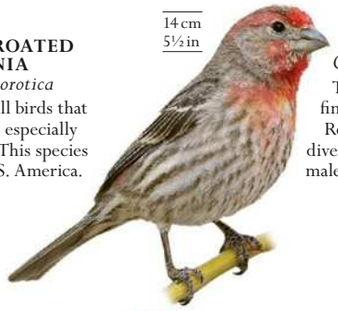
37–46 cm
14½–18 in

CRESTED OROPENDOLA
Psarocolius decumanus
Like other tropical American oropendolas, this colonial species weaves long nests that hang from tips of branches in open forest.

BLUE-NAPED CHLOROPHONIA
Chlorophonia cyanea
The fruit-eating chlorophonias are mainly green birds. This species is widespread in forests across S. America.



PURPLE-THROATED EUPHONIA
Euphonia chlorotica
Euphonias are small birds that mainly eat fruits, especially mistletoe berries. This species is from northern S. America.

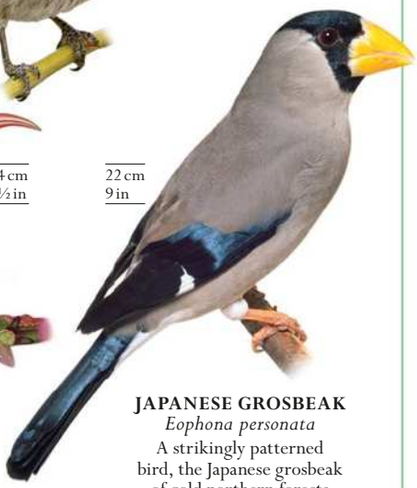


HOUSE FINCH
Carpodacus mexicanus
The N. American house finch is a type of rosefinch. Rosefinches are especially diverse in temperate Asia. The males are red or pale coloured.

PINE GROSBEAK
Pinicola enucleator
The pine grosbeak occurs in coniferous forests in the northern hemisphere. The bill of this grosbeak resembles that of the closely related bullfinches.

EURASIAN BULLFINCH
Pyrrhula pyrrhula
Bullfinches have a short, thick bill and a thick-set head. This is the most widespread of the bullfinches and is found in woodlands across temperate Eurasia.

IIWI
Drepanis coccinea
This long-billed nectar-eater is found only in Hawaii. It is a bird of montane forests, the largest populations occurring at higher elevations.



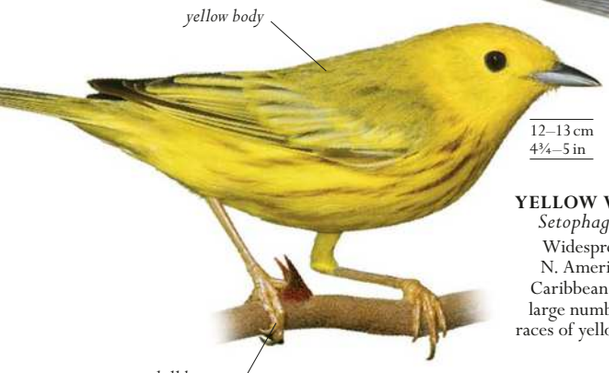
JAPANESE GROSBEAK
Eophona personata
A strikingly patterned bird, the Japanese grosbeak of cold northern forests breeds in Siberia and N. Japan and winters in S. China.

AMERICAN WARBLERS

Unrelated to warblers of the Old World, these finch-related insect-eaters of the family Parulidae are found throughout North and South America. The tropical species are sedentary, but temperate ones are migratory. The males moult their bright colours in winter.

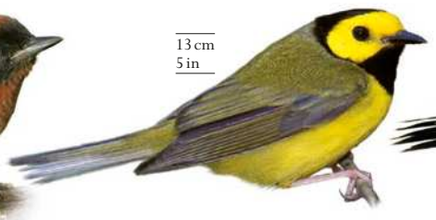
BLACK-AND-WHITE WARBLER
Mniotilta varia
This N. American warbler moves up and down tree trunks like a nuthatch, and has long hind claws for clinging to bark.

YELLOW-BREASTED CHAT
Icteria virens
This N. American bird is relatively large for a warbler. It sings at night as well as during the day, and mimics the calls of other birds.



YELLOW WARBLER
Setophaga aestiva
Widespread from N. America to the Caribbean, there is a large number of local races of yellow warblers.

BAY-BREASTED WARBLER
Setophaga castanea
This bird breeds in spruce forests in eastern N. America. Its numbers fluctuate according to the abundance of its prey, the spruce budworm.



HOODED WARBLER
Setophaga citrina
Like the American redstart, this bird from broadleaf woodland of the E. USA feeds on insects by catching flies while in flight.

AMERICAN REDSTART
Setophaga ruticilla
An active forager, this N. American warbler habitually flashes its orange and black wings and tail to flush out insects. It also catches prey in the air.

NORTHERN WATERTHRUSH
Parkesia noveboracensis
A large, tail-bobbing ground warbler of N. America, this bird forages in leaf litter of wet woodlands and nests in thickets near water.

PROTHONOTARY WARBLER
Protonotaria citrea
Unusually for American warblers, this species of densely wooded swamps nests in tree cavities – sometimes using old woodpecker holes.

COMMON YELLOWTHROAT
Geothlypis trichas
A bird of wet habitats, this is a migratory species like other N. American warblers. It winters in California and Mexico.

GOLDEN-WINGED WARBLER
Vermivora chrysoptera
A warbler of eastern N. America, this bird breeds in scrubby, open habitats and farmland, and benefits from deforestation.

BUNTINGS AND RELATIVES

True buntings of the Old World in the family Emberizidae are mostly ground-feeding seed-eaters. Longspurs, in both Old and New Worlds, are similar short-legged ground birds of open spaces, from plains and tundra to mountain tops in the family Calcaridae.

BLACK-HEADED BUNTING
Emberiza melanocephala
An inhabitant of scrub and olive groves, the black-headed bunting breeds in the Middle East and winters in India.

LAPLAND LONGSPUR
Calcarius lapponicus
Relatives of buntings, longspurs have been named for their long hind claw. This species has a circumpolar distribution during the breeding season.

AMERICAN SPARROWS

Birds in the family Passerellidae resemble Old World buntings rather than true sparrows, especially in the bill structure, with a small, sharp upper mandible and often slightly kinked cutting edge. Many also have striped head patterns, with or without streaked flanks – others are more uniform in colour. They search for seeds while hopping on the ground.

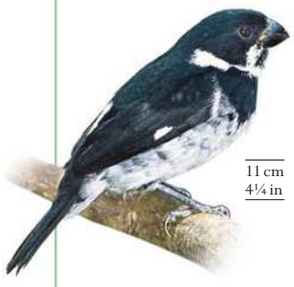
DARK-EYED JUNCO
Junco hyemalis
Juncos are grey-brown, ground-flocking N. American sparrows. This species, locally called the snowbird, is a common winter visitor of garden bird feeders.

YELLOW-THIGHED FINCH
Pselliophorus tibialis
A noisy, tropical member of the American sparrow family, this species is found only in the montane rainforests of Costa Rica and Panama.

SPOTTED TOWHEE
Pipilo maculatus
Towhees are long-tailed American sparrows. The spotted towhee is a reddish brown-sided bird found in thicket habitats across N. America.

TANAGERS AND RELATIVES

An American family, the Thraupidae consist of gaudily coloured tanagers, found in the forests of tropical South America. These finch-related birds have evolved to exploit a range of food sources, including fruits, insects, seeds, and nectar.



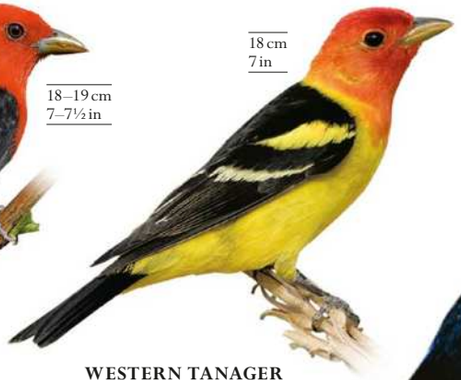
VARIABLE SEED-EATER
Sporophila corvina
Belonging to a group of tropical American, stubby-billed seed-eaters, this bird has a variable plumage pattern.

BLACK-MASKED FINCH
Coryphaspiza melanotis
A ground-feeding finch of grassland habitats in central S. America, this species has been assigned to the tanager family.

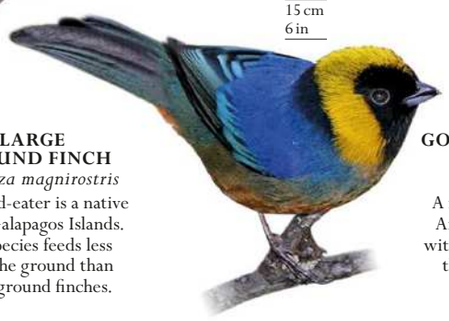
LARGE GROUND FINCH
Geospiza magnirostris
This seed-eater is a native of the Galapagos Islands. The species feeds less from the ground than other ground finches.

GREEN HONEYCREEPER
Chlorophanes spiza
This stocky species lives in forest canopy and uses its stout, decurved bill to eat fruits. It is often seen in mixed flocks of tanagers.

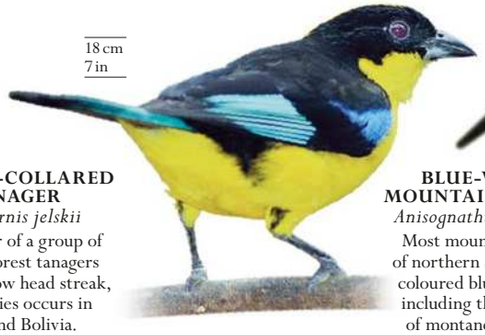
SCARLET TANAGER
Piranga olivacea
In most species of *Piranga* tanager, the males turn red during breeding. This migratory species is from N. America.



WESTERN TANAGER
Piranga ludoviciana
This bird breeds in western N. America and overwinters in C. America. It is the only *Piranga* tanager where the breeding male is predominantly yellow.



GOLDEN-COLLARED TANAGER
Iridosornis jelskii
A member of a group of Andean forest tanagers with a yellow head streak, this species occurs in Peru and Bolivia.



BLUE-WINGED MOUNTAIN TANAGER
Anisognathus somptuosus
Most mountain tanagers of northern S. America are coloured blue and yellow, including this inhabitant of montane rainforests.

17–19 cm
6½–7½ in

FOX SPARROW
Passerella iliaca
Widespread throughout N. America, this large sparrow has a red-streaked back and chest. It usually forages in low vegetation.

pale grey band above eye

long, rounded, plain tail

variably coloured belly, streaked blackish, brown, or red

14–16 cm
5½–6½ in

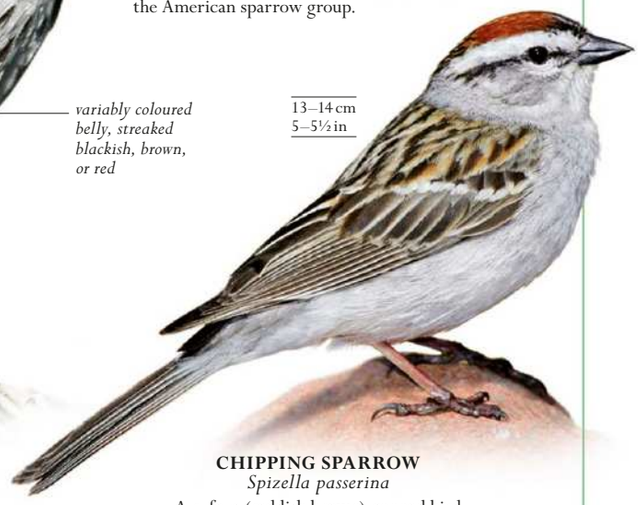
18 cm
7 in

LARK-BUNTING
Calamospiza melanocorys
A bird of the N. American prairies, the lark-bunting is a ground-nesting member of the American sparrow group.

17–19 cm
6½–7½ in

WHITE-CROWNED SPARROW
Zonotrichia leucophrys
This N. American bird is usually found in low vegetation or on the ground. It has distinctive black and white head markings.

SONG SPARROW
Melospiza melodia
A common N. American bird from Alaska to Mexico, this species has a large number of races. It is named for its melodious song.



13–14 cm
5–5½ in

CHIPPING SPARROW
Spizella passerina
A rufous (reddish brown)-capped bird common in open woodland across N. America, the chipping sparrow has a distinctive "chipping" trill.

CARDINALS AND RELATIVES

These mostly chunky-billed birds are seed-eaters like buntings, and many have bright colours like tanagers. Related to both, the Cardinalidae belong to a large group of American passerines that are derived from finches.

breeding male has blue underparts and head

19 cm
7½ in

13 cm
5 in

RED-CRESTED CARDINAL
Paroaria coronata
Birds of the *Paroaria* genus are found in S. America. This is a common species in open woodland.

RED-LEGGED HONEYCREEPER
Cyanerpes cyaneus
Tropical American honeycreepers feed on nectar. The most widespread species, this bird has a decurved bill. Like females, males develop a dull green "eclipse" plumage after breeding.

13 cm
5 in

BLUE-NECKED TANAGER
Tangara cyanicollis
This open forest bird from northern S. America belongs to a group of tanager species with particularly colourful, iridescent plumage.

18–21 cm
7–8½ in

ROSE-BREASTED GROSBEAK
Pheucticus ludovicianus
This migratory American cardinal grosbeak has a typically heavy bill for feeding on large seeds and on insects, such as beetles.

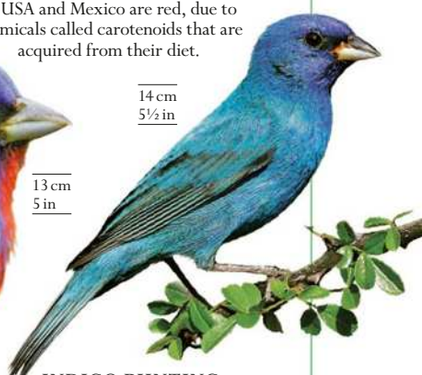
21–23 cm
8½–9 in

NORTHERN CARDINAL
Cardinalis cardinalis
The males of this resident of the E. USA and Mexico are red, due to chemicals called carotenoids that are acquired from their diet.

green back

13 cm
5 in

PAINTED BUNTING
Passerina ciris
This species breeds in the S. USA and overwinters in C. America and the Caribbean. Only males have the striking tricoloured pattern.



14 cm
5½ in

INDIGO BUNTING
Passerina cyanea
The most wide ranging of the blue buntings, this species migrates between Canada and S. America. The males lose their blue plumage in winter.

MAMMALS

The mammals are very successful animals. They are able to occupy almost every terrestrial habitat, and some visit the deep oceans between breaths of air. However, this has not always been the case; at 210 million years old, mammals are a relatively recent group.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDERS	28
FAMILIES	160
SPECIES	About 6,300

A single jawbone articulated directly to the skull gives mammals, such as this Tasmanian devil, a powerful bite.

Baleen is made of a protein called keratin, and baleen whales use it to strain sea water, trapping food in their mouth.

By sucking milk from their mother, young warthogs obtain all the nourishment they need during the first weeks of life.

DEBATE

EQUALLY WELL ADAPTED

Marsupial features are sometimes described as primitive. This implies that marsupials, whose young are born in an embryonic state and develop in a pouch, are less advanced than placental mammals, which bear conventional young. In fact, the two groups emerged at the same time about 175 million years ago.

Mammals owe their success to a unique combination of adaptations that allowed them to replace reptiles as the dominant form of animal life on Earth. Like reptiles, mammals breathe air, but unlike their scaly ancestors, they are warm-blooded, so they are able to burn fuel (food) in order to maintain a constant, warm body temperature. This creates conditions in which the internal chemical processes that sustain life can happen most efficiently, without relying directly on heat from the sun. Uniquely, mammals have hair, which reduces heat loss and allows an animal to be active in cold climates and at night. Because fur can be moulted and regrown, it is seasonally adjustable too.

VARIATIONS ON A THEME

The basic mammal skeleton is strong, with upright limbs supporting the body from below. This arrangement allows land-dwelling mammals to walk, run, and leap, but the basic structure is highly adaptable, and has been modified for swimming, as in seals and cetaceans; for flying, as in bats; and for climbing or swinging through the trees, as in some primates. The mammalian skull has powerful jaws, with a single lower jawbone articulating directly with the skull, and a diverse range of teeth adapted to a huge variety of food types. Certain other bones, which in reptiles contribute to the lower jaw, are put to a new use by mammals – they have became the three tiny bones of the inner ear, allowing for greatly enhanced hearing. The mammalian skull also serves to protect the brain, which is larger in mammals than in other groups, hinting at increased processing power. With a big brain comes intelligence, and an unrivalled ability to learn, to remember, and to engage in complex behaviour.

These abilities take time to fine-tune, and young mammals do so during the extended period of parental care that begins while they are being fed on milk produced by their mother's mammary glands. These unique organs evolved from sebaceous glands, which originally provided secretions to condition the skin and perhaps to prevent eggs drying out, and it is for them that the entire group is named.

FUR AS INSULATION >
The air trapped in a sea otter's dense fur insulates it from the cold water in which it lives.

MAMMAL GROUPS

There are three groups of mammals – the egg-laying monotremes, the pouched mammals (or marsupials), and the placental mammals. The latter group is the most diverse, and is here divided into further groups.

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EGG-LAYING MAMMALS

There are just five species in this group of mammals, which are known as monotremes. All of them have a specialized snout and lay eggs.

The monotremes, which are the duck-billed platypus and the long-nosed and short-nosed echidnas, form the order Monotremata. They are found in various habitats in New Guinea, Australia, and Tasmania.

Platypuses and echidnas lay soft-shelled eggs that hatch after around ten days' incubation. The young feed on milk secreted from the female's mammary glands; monotremes have no teats. Infant echidnas live in their mother's pouch until their spines appear and then, like young platypuses, stay in a burrow for several months.

Monotremes have a specialized snout for finding and eating prey. The platypus, which is partly aquatic, has a flattened, duck-like bill covered with sensory receptors that allow the animal to locate invertebrates under water, even in murky conditions. The long, cylindrical snout and long tongue of the land-dwelling echidnas are ideal for probing the nests of ants and termites, and for catching worms. Neither the platypus nor the echidnas have teeth; instead they have grinding surfaces or horny spines on their tongue.

WHAT'S IN A NAME

The word "monotreme" means "single hole" and makes reference to the cloaca, a single posterior body opening into which the digestive, urinary, and reproductive tracts empty.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	MONOTREMATA
FAMILIES	2
SPECIES	5

The large, webbed forefeet of the duck-billed platypus provide propulsion. The hind feet and tail are used to steer.

DUCK-BILLED PLATYPUS

The sole member of the family Ornithorhynchidae, the duck-billed platypus is well adapted to a semi-aquatic lifestyle. It has a streamlined body, waterproof fur, webbed feet, and a flattened tail. Males have a venomous horny spur on each hind foot.

DUCK-BILLED PLATYPUS
Ornithorhynchus anatinus
Found in rivers and streams in E. Australia and Tasmania, this rare species uses its soft bill, which is covered in electroreceptors, to hunt for invertebrates.

ECHIDNAS

The family Tachyglossidae is made up of the long- and short-beaked echidnas. Their rounded body is covered with fur and spines, and the long snout is ideal for seeking out insects, ants, and worms.

SHORT-BEAKED ECHIDNA
Tachyglossus aculeatus
Widespread in Australia, Tasmania, and New Guinea, the short-beaked echidna lays a single egg into a pouch on its abdomen.

EASTERN LONG-BEAKED ECHIDNA
Zaglossus bartoni
The largest of the monotremes, this species lives in the forested highlands of E. New Guinea.

POUCHED MAMMALS

These mammals bear live young that are born in a very immature state, and typically complete their growth in the mother's abdominal pouch.

Marsupials inhabit a vast array of habitats from desert and dry scrub to tropical rainforest. Most of them are either terrestrial or arboreal, but several glide, one is aquatic, and there are two marsupial moles that live underground. The diets of marsupials are equally wide-ranging: among the different species are carnivores, insectivores, herbivores, and omnivores. There are even marsupials that feed on nectar and pollen. Marsupials also differ markedly in size, from the tiny planigales, which are among the smallest mammals in the world, weighing less than 4.5 g (about ⅓ oz), to the red kangaroo, males of which can weigh over 90 kg (200 lb).

EARLY DEVELOPMENT

Young marsupials are born blind and furless. They make their way through the mother's fur and latch on to a nipple and suckle. In around half of marsupial species, the nipples are located in a protective pouch. Some marsupials have only one offspring at a time, but others may have up to a dozen or more. The phase during which young are in the pouch is equivalent to the gestation period of placental mammals.

Kangaroos and some other marsupials are able to stop the development of an embryo before it implants in the uterus if they already have an infant occupying the pouch. The pregnancy continues when the pouch is vacated.

THE SEVEN ORDERS

Pouched mammals, known as marsupials, are now divided into seven major groups. These are: the American opossums, order Didelphimorphia; the shrew opossums, order Paucituberculata; monito del monte, the sole member of the order Microbiotheria; the Australasian carnivorous marsupials, order Dasyuromorphia; bandicoots, order Peramelemorphia; the marsupial moles, order Notoryctemorphia; and the Australasian marsupials of Diprotodontia, the largest order of pouched mammals, which includes the koala, wombats, possums, wallabies, and kangaroos.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDERS	7
FAMILIES	18
SPECIES	OVER 350

DEBATE

NOT SO PRIMITIVE?

Pouched mammals were once considered primitive because their young are born at an early stage without prolonged nourishment by a placenta inside the mother. Scientists now know that this reproductive strategy is an adaptation to their environment and that pouched mammals are just as advanced as placental mammals. Kangaroos can support two dependent juveniles of different ages, and a fertile egg that can develop almost immediately should anything happen to the other two. This strategy means pouched mammals recover quickly when harsh environmental conditions abate.

SHREW OPOSSUMS

Fewer incisor teeth distinguish the members of the family Caenolestidae from other American marsupials. All eight species occur in the Andes in western S. America.

9–14 cm
3½–5½ in

DUSKY SHREW OPOSSUM
Caenolestes fulginosus
Living at high altitudes in Colombia, Ecuador, and Venezuela, this shrew opossum uses its large lower incisors to kill prey.

MONITO DEL MONTE

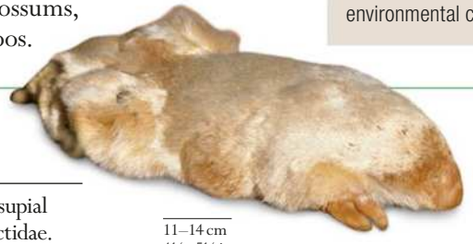
The sole member of the family Microbiotheriidae, the monito del monte is well adapted to the cold. It uses both daily torpor and seasonal hibernation to conserve energy when temperatures are low or food is in short supply.

8–13 cm
3¼–5 in

MONITO DEL MONTE
Dromiciops gliroides
Inhabiting cool bamboo forest and temperate rainforest in Chile and Argentina, this species has dense fur to limit heat loss.

MARSUPIAL MOLES

Two species of Australian marsupial moles form the family Notoryctidae. Their short limbs, large claws, and horned nose-shield help them to burrow. They lack external ears and have non-functional eyes.



11–14 cm
4½–5½ in

SOUTHERN MARSUPIAL MOLE
Notoryctes typhlops
This marsupial mole is specialized for burrowing in the sandy desert and spinifex grassland of C. Australia.

OPOSSUMS

The New World opossums of the family Didelphidae have a pointed muzzle with sensitive whiskers, and naked ears. Many species have a grasping, prehensile tail that helps when climbing. Some opossums lack pouches.

37–50 cm
14½–20 in

VIRGINIA OPOSSUM
Didelphis virginiana
The largest American marsupial, this species lives in grasslands and temperate and tropical forests in the USA, Mexico, and C. America.

20–32 cm
8–12½ in

BROWN-EARED WOOLLY OPOSSUM
Caluromys lanatus
Also known as the western woolly opossum, this arboreal, solitary opossum inhabits moist forests in western and central S. America.

16–28 cm
6½–11 in

BARE-TAILED WOOLLY OPOSSUM
Caluromys philander
This woolly opossum's long, prehensile tail helps it move through the canopy of moist rainforests across eastern and central S. America.

»

» OPOSSUMS

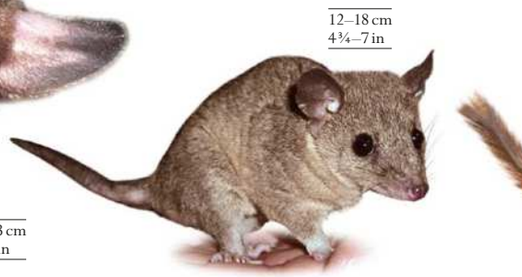
LINNAEUS'S MOUSE OPOSSUM
Murinus murina
Widespread in forests, pampas, and plantations in S. America, this agile, nocturnal climber has a long, prehensile tail.

WOOLLY MOUSE OPOSSUM
Marmosa sp.
Living in C. and S. America, this pouchless marsupial with thick, woolly fur is arboreal, nocturnal, and omnivorous.

WATER OPOSSUM
Chironectes minimus
The only aquatic marsupial, this opossum of C. and S. America is also unique in that both sexes have a pouch, but it is only watertight in females.

ELEGANT FAT-TAILED MOUSE OPOSSUM
Thylamys elegans
Like several other opossums, this marsupial from Chile stores fat in its tail as winter approaches.

PATAGONIAN OPOSSUM
Lestodelphys halli
Living in shrub, savanna, and grassland in Argentina, the Patagonian opossum has the most southerly distribution of any opossum species.



GREY FOUR-EYED OPOSSUM
Philander opossum
This opossum has white spots on its forehead, making it look as if it has four eyes. It lives in Mexico, and C. and S. America.

GREY SHORT-TAILED OPPOSUM
Monodelphis domestica
Found in Argentina, Brazil, Bolivia, and Paraguay, this short-tailed opossum sometimes inhabits human dwellings, as well as forest, scrub, and grassland.

NUMBAT

The numbat is the only member of the family Myrmecobiidae. It has a distinctive striped coat, strong claws for digging, and a very long tongue for extracting termites from their nests.

NUMBAT
Myrmecobius fasciatus
Found only in eucalyptus forest and woodland in Western Australia, this diurnal marsupial is a specialized termite-eater.

BILBIES

The family Thylacomyidae has only one species, since the lesser bilby has been declared extinct. Living in arid habitats, this nocturnal marsupial does not need to drink water, as it absorbs moisture from its food.

GREATER BILBY
Macrotis lagotis
A burrowing species of the desert of C. Australia, this marsupial has silky fur, a tricoloured tail, and long, rabbit-like ears.

QUOLLS, DUNNARTS, AND RELATIVES

With strong jaws and sharp canine teeth, the family Dasyuridae is made up of more than 70 large and small carnivorous marsupials. These animals also have sharp claws, except on their big toe.

TASMANIAN DEVIL
Sarcophilus harrisii
The largest carnivorous marsupial in the world, this nocturnal hunter lives in a variety of habitats across Tasmania.

57–65 cm
22½–26 in

9.5–10.5 cm
3¾–4¼ in

FAT-TAILED FALSE ANTECHINUS
Pseudantechinus macdonnellensis
This nocturnal insect-eater stores fat in the base of its tapered tail. It inhabits arid rocky habitats of C. and W. Australia.

7–14 cm
2¾–5½ in

BROWN ANTECHINUS
Antechinus stuartii
Antechinus males die of stress and exhaustion after their first breeding season. This species is endemic to forests in E. Australia.

THREE-STRIPED DASYURE
Myoictis sp.
This marsupial's coloration helps it to remain camouflaged on the rainforest floor in the islands of Indonesia and New Guinea.

26–40 cm
10–16 in

WESTERN QUOLL
Dasyurus geoffroii
Also called the chuditch, this nocturnal hunter from S.W. Australia is mainly ground-dwelling, although it can climb trees.

19–24 cm
7½–9½ in

RED-TAILED PHASCOGALE
Phascogale calura
Possessing a brush of black hair on its red-based tail, this carnivorous marsupial inhabits woodland in S.W. Australia.

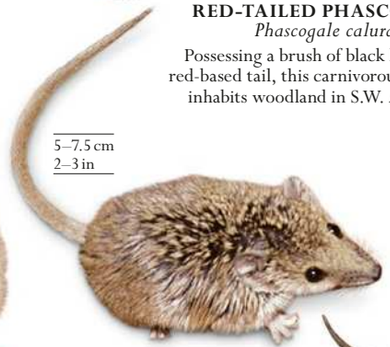
10.5–12.5 cm
4¼–5 in

12–23 cm
4¾–9 in

CREST-TAILED MULGARA
Dasycercus cristicauda
This carnivore from W. and C. Australia inhabits arid and semi-arid habitats, such as desert, heath, and grassland. It stores fat in its tail.

7–10 cm
2¾–4 in

KULTARR
Antechinomys laniger
This fast, agile marsupial uses its large hind feet to bound across woodland, grassland, and semi-desert habitats in southern and C. Australia.



5–7.5 cm
2–3 in

NARROW-NOSED PLANIGALE
Planigale tenuirostris
This flat-headed, nocturnal, rodent-like marsupial lives in low shrub and dry grassland in S.E. Australia.

5–7.5 cm
2–3 in

INLAND NINGAUI
Ningaui ridei
A shrew-like marsupial with a pointed snout, this nocturnal predator hunts insects in arid spinifex grassland in C. Australia.

6–9 cm
2¼–3½ in

FAT-TAILED DUNNART
Sminthopsis crassicaudata
Living in open grassland in southern Australia, this small, nocturnal marsupial stores fat reserves in its tail.

BANDICOOTS

These omnivorous marsupials are found across Australia and New Guinea. Characterized by fused second and third toes on their hind feet and three pairs of lower incisor teeth, the Peramelidae also have short, coarse, or spiny hair.

22.5–38 cm
9–15 in

SPINY BANDICOOT
Echymipera kalubu
This forest-dwelling, nocturnal insect-eater of New Guinea has a conical snout, spiny coat, and a hairless tail.

28–36 cm
11–14 in

SOUTHERN BROWN BANDICOOT
Isoodon obesulus
This short-nosed bandicoot lives in the shrubby heathland in southern Australia and several islands, including Kangaroo Island and Tasmania.

31–44.5 cm
12–17½ in

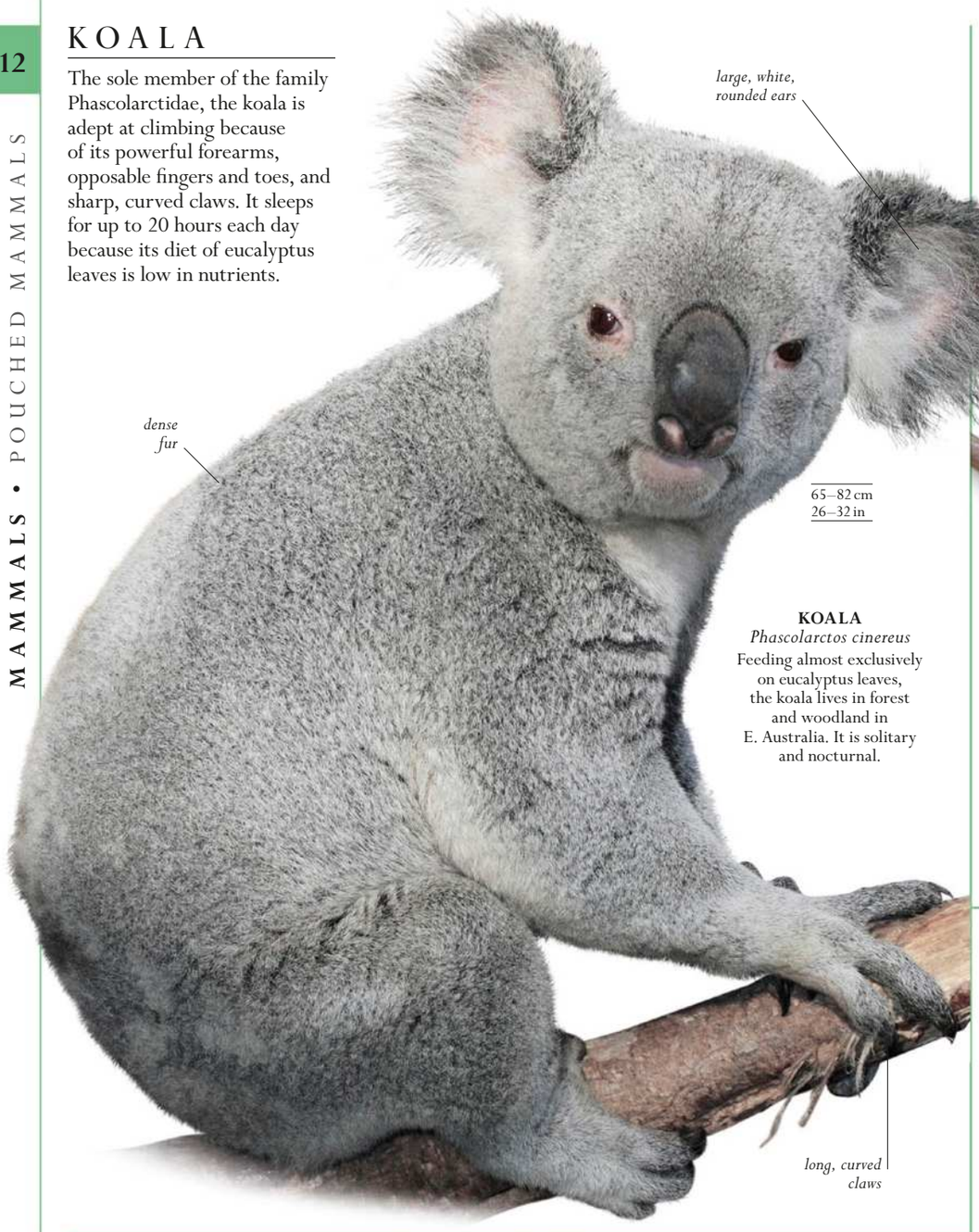
LONG-NOSED BANDICOOT
Perameles nasuta
Found in rainforest and woodland in eastern coastal Australia, this nocturnal bandicoot forages for food by digging for insects.

27–35 cm
10½–14 in

EASTERN BARRED BANDICOOT
Perameles gunnii
Named for the creamy bands of fur on its flanks, this bandicoot lives in grassland and grassy woodland in Australia and Tasmania.

KOALA

The sole member of the family Phascolarctidae, the koala is adept at climbing because of its powerful forearms, opposable fingers and toes, and sharp, curved claws. It sleeps for up to 20 hours each day because its diet of eucalyptus leaves is low in nutrients.



65–82 cm
26–32 in

KOALA
Phascolarctos cinereus
Feeding almost exclusively on eucalyptus leaves, the koala lives in forest and woodland in E. Australia. It is solitary and nocturnal.

PYGMY POSSUMS

These small, nocturnal marsupials with a prehensile tail are omnivorous, feeding on insects, fruits, nectar, and pollen. Four species of the family Burramyidae are endemic to Australia; the fifth lives in Australia and New Guinea.

10.5 cm
4¼ in

LONG-TAILED PYGMY POSSUM
Cercartetus caudatus
This arboreal marsupial is found in temperate rainforest in New Guinea and N.E. Queensland.

10–13 cm
4–5 in

MOUNTAIN PYGMY POSSUM
Burramys parvus
A ground-dweller of rocky, upland habitats in Australia, the mountain pygmy possum hibernates under snow for several months during winter.

RINGTAILS AND RELATIVES

This family consists of ringtail possums and the lemur-like greater glider. The Pseudocheiridae are all arboreal and are specialized leaf-eaters. They have an enlarged pouch at the start of the large intestine for fermentation of cellulose from their diet.

COMMON RINGTAIL
Pseudocheirus peregrinus
This agile marsupial lives in a wide range of habitats in E. Australia and Tasmania. It has become a pest in New Zealand.

29–35 cm
11½–14 in

35–55 cm
14–22 in

LEMUROID RING-TAILED POSSUM
Hemibelideus lemuroides
Found only in a small area of rainforest in N.E. Queensland, Australia, this species of ringtail is nocturnal.

WOMBATS

Stocky marsupials with a short tail and short limbs, wombats have large forepaws and long claws for burrowing. The family Vombatidae feed on coarse grass, which they grind using strong jaws, and digest with an elongated gut.

90–115 cm
35–45 in

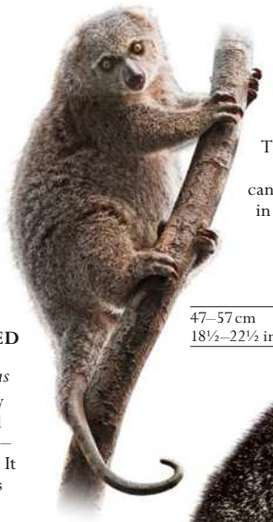
COMMON WOMBAT
Vombatus ursinus
Found in forest, heathland, and coastal scrub in S.E. Australia, this species is capable of digging tunnels up to 200 m (655 ft) long.

84–111 cm
33–43 in

SOUTHERN HAIRY-NOSED WOMBAT
Lasiorhinus latifrons
An inhabitant of central southern Australia, this wombat lives colonially in warrens but feeds alone.

CUSCUS AND RELATIVES

The family Phalangeridae includes cuscuses, brushtail possums, and their relatives. Most members are arboreal, with an opposable thumb on the hind limbs and a prehensile tail. In cuscuses, part or all of the tail is naked, whereas in brushtail possums the tail has fur.



SULAWESI BEAR CUSCUS
Ailurops ursinus
The largest of the cuscuses, this species inhabits the canopy of temperate rainforest in Sulawesi and several other Indonesian islands.

47–57 cm
18½–22½ in

large eyes assist sight at night

42–74 cm
16½–29 in

COMMON SPOTTED CUSCUS
Spilocuscus maculatus
This cuscus is sexually dimorphic (males and females look different) – only the male has spots. It lives in the rainforests of New Guinea and N.E. Australia.

49–54 cm
19½–21½ in

strong, curved claws

furry tail

MOUNTAIN BRUSHTAIL POSSUM
Trichosurus cunninghami
The mountain brushtail possum inhabits dense, wet forests in S.E. Australia, typically living at altitudes above 300 m (985 ft).

30–47 cm
12–18½ in

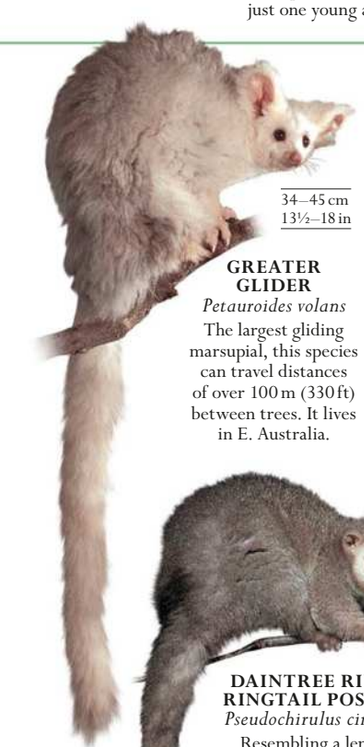
SCALY-TAILED POSSUM
Wyulda squamicaudata
Found only in the Kimberley in N.W. Australia, this nocturnal possum is solitary and bears just one young at a time.

33–60 cm
13–23½ in

CUSCUS
Phalanger sp.
Cuscuses of this genus live on New Guinea and nearby islands. They live at different altitudes to avoid competition with one another.

GLIDING AND STRIPED POSSUMS

The Petauridae include striped possums and gliders, except the greater glider (left). Gliders have a thin, furred membrane between their fore and hind limbs. Striped possums emit strong smells and have an elongated fourth finger to probe for wood-boring beetles.



34–45 cm
13½–18 in

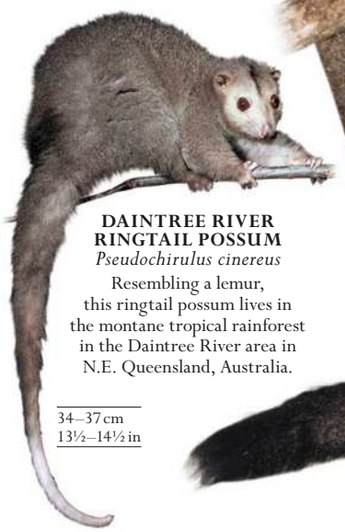
GREATER GLIDER
Petauroides volans
The largest gliding marsupial, this species can travel distances of over 100 m (330 ft) between trees. It lives in E. Australia.

grizzled, grey fur

32–40 cm
12½–16 in

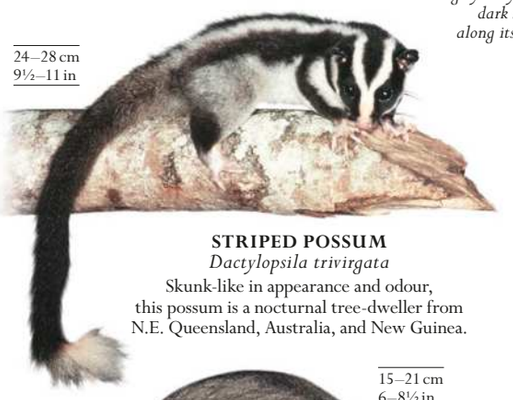
GREEN RINGTAIL
Pseudochirops archeri
Named for its thick, greenish fur, this solitary possum is found only in rainforest in the far north of Queensland, Australia.

prehensile tail



34–37 cm
13½–14½ in

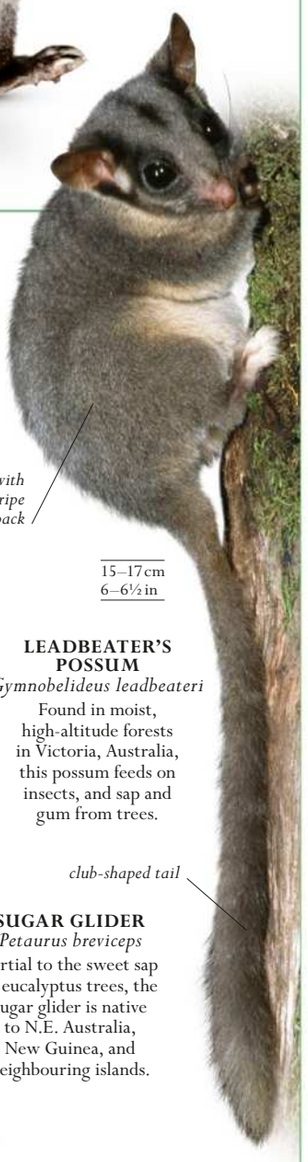
DAINTREE RIVER RINGTAIL POSSUM
Pseudochirulus cinereus
Resembling a lemur, this ringtail possum lives in the montane tropical rainforest in the Daintree River area in N.E. Queensland, Australia.



24–28 cm
9½–11 in

STRIPED POSSUM
Dactylopsila trivirgata
Skunk-like in appearance and odour, this possum is a nocturnal tree-dweller from N.E. Queensland, Australia, and New Guinea.

grey body with dark stripe along its back



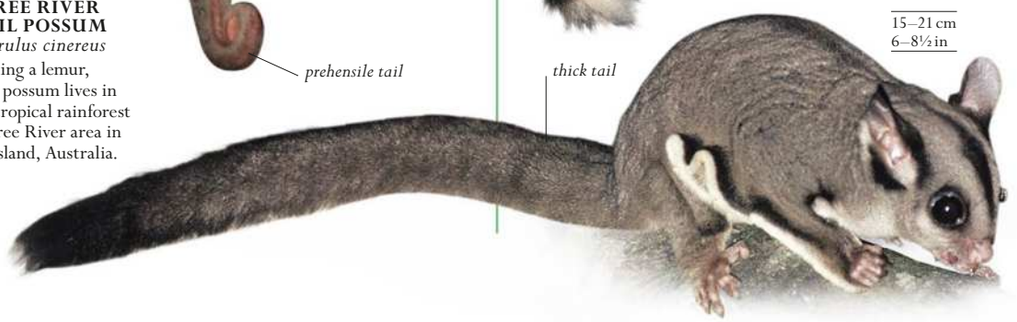
15–17 cm
6–6½ in

LEADBEATER'S POSSUM
Gymnobelideus leadbeateri
Found in moist, high-altitude forests in Victoria, Australia, this possum feeds on insects, and sap and gum from trees.

15–21 cm
6–8½ in

thick tail

club-shaped tail



SUGAR GLIDER
Petaurus breviceps
Partial to the sweet sap of eucalyptus trees, the sugar glider is native to N.E. Australia, New Guinea, and neighbouring islands.

HONEY POSSUM

This diminutive species is the only member of the family Tarsipedidae. It has fewer teeth than other possums and a long, brush-covered tongue for probing flowers.

HONEY POSSUM
Tarsipes rostratus
Inhabiting heathland and woodland in S.W. Australia, this possum is a specialized feeder on nectar and pollen.

FEATHER-TAILED GLIDERS

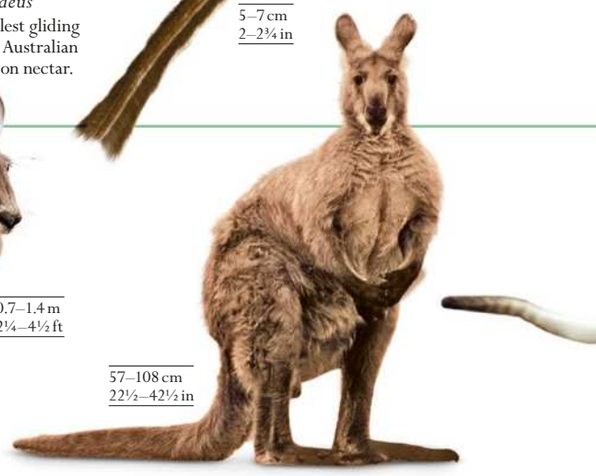
The family Acrobatidae contains three species – the feather-tailed or pygmy glider, the broad-toed feathertail glider, and the feather-tailed possum. All have tails fringed with rows of stiff hairs.

FEATHER-TAILED GLIDER
Acrobates pygmaeus
This species is the smallest gliding marsupial. It lives in E. Australian forests, where it feeds on nectar.

KANGAROOS AND RELATIVES

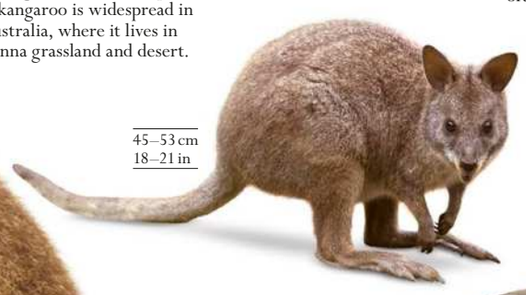
The kangaroos and wallabies of the family Macropodidae are medium to large animals, with long hind legs for jumping. The hind feet lack a first toe, a fleshy sheath encompasses the second and third toes, forming a short grooming claw, and the strong, elongated fourth and fifth toes are weight-bearing.

RED KANGAROO
Osphranter rufus
The largest extant marsupial, this kangaroo is widespread in Australia, where it lives in savanna grassland and desert.

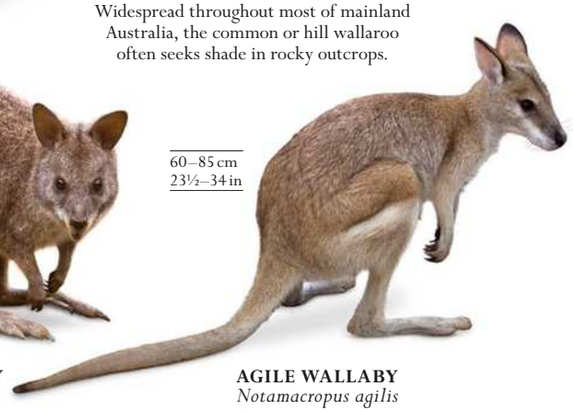


COMMON WALLAROO
Osphranter robustus
Widespread throughout most of mainland Australia, the common or hill wallaroo often seeks shade in rocky outcrops.

RED-NECKED WALLABY
Notamacropus rufogriseus
This species lives in coastal forest and scrub in southeastern Australia, including the islands of Tasmania and the Bass Strait.



PARMA WALLABY
Notamacropus parma
Native to the mountains of the Great Dividing Range in Australia, the parma wallaby inhabits a range of forest habitats.



AGILE WALLABY
Notamacropus agilis
Unusually for wallabies, this species occurs in both Australia and New Guinea, where it inhabits grassland and open woodland.

EASTERN GREY KANGAROO
Macropus giganteus
Widespread in E. Australia, this species lives in dry woodland, scrub, and shrub. A subspecies is found in Tasmania.

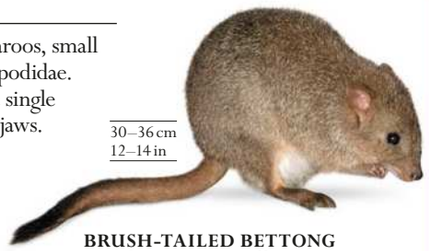
WESTERN GREY KANGAROO
Macropus fuliginosus
The only kangaroo that does not reproduce using the method of delayed implantation of the embryo in the uterus, this species occurs in southern Australia, including Kangaroo Island.

POTOROOS

This family contains potoroos, bettongs, and rat kangaroos, small marsupials with many similarities to the larger Macropodidae. However, unlike them, the Potoroidae as adults have a single serrated upper and lower premolar in each side of the jaws.

26–41 cm
10–16 in

LONG-NOSED POTOROO
Potorous tridactylus
Inhabiting heath and forest in S.E. Australia, this potoroo has strong, curved claws that help it to dig for underground fungi.



30–36 cm
12–14 in

BRUSH-TAILED BETTONG
Bettongia penicillata
This bettong lives in forest and grassland in S.W. Australia. It has a prehensile tail that it uses for moving nesting material.

RAT-KANGAROO

The musky rat-kangaroo is the sole member of the family Hypsiprymnodontidae. It is relatively primitive; unlike other kangaroo species, it has a first toe, which is opposable and helps it grip.

15–28 cm
6–11 in

MUSKY RAT-KANGAROO
Hypsiprymnodon moschatus
This diurnal species inhabits tropical rainforest in N. Queensland, Australia, where it forages for fallen fruits, seeds, and fungi.

49–69 cm
19½–27 in

NORTHERN NAIL-TAILED WALLABY
Onychogalea unguifera
Also called the sandy nail-tailed wallaby, this medium-sized kangaroo occurs across N. Australia.

34–109 cm
13½–43 in

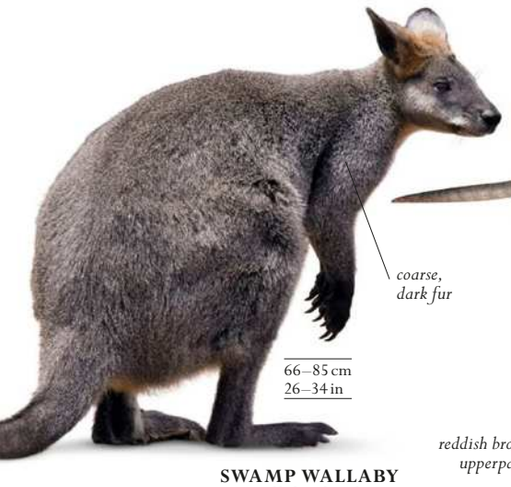
BRIDLED NAIL-TAIL WALLABY
Onychogalea fraenata
This nocturnal wallaby was once thought to be extinct; the only remaining wild population is in a small area of Queensland, Australia.

RED-NECKED PADEMELON
Thylogale thetis
A forest wallaby from eastern Australia, this species ventures to the forest edge at night to feed on grass, leaves, and shoots.

29–63 cm
11½–25 in

muscular thighs

long, narrow sole of foot

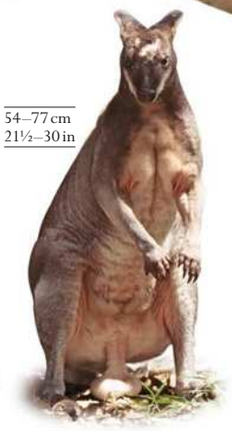


66–85 cm
26–34 in

coarse, dark fur

31–39 cm
12–15½ in

RUFOUS HARE-WALLABY
Lagorchestes hirsutus
Previously inhabiting the Australian mainland, the mala or rufous hare-wallaby now exists in the wild on only two islands in Western Australia.



54–77 cm
21½–30 in

BROWN DORCOPSIS
Dorcopsis muelleri
This forest-dwelling kangaroo is endemic to the low-altitude rainforests of western New Guinea, and three offshore islands.

40–54 cm
16–21½ in

QUOKKA
Setonix brachyurus
Rare in mainland Australia, this small marsupial is found on Rottnest and Bald Islands, off the southwestern coast.

55–78 cm
22–30¾ in

DORIA'S TREE KANGAROO
Dendrolagus dorianus
The heaviest of the tree-dwelling marsupials, Doria's tree kangaroo frequently descends to the ground. It lives in montane forest in New Guinea.

51–62 cm
20–24 in

BRUSH-TAILED ROCK WALLABY
Petrogale penicillata
This resident of S.E. Australia has roughened, padded hind feet that help it to grip when jumping in rocky habitats.

reddish brown upperparts

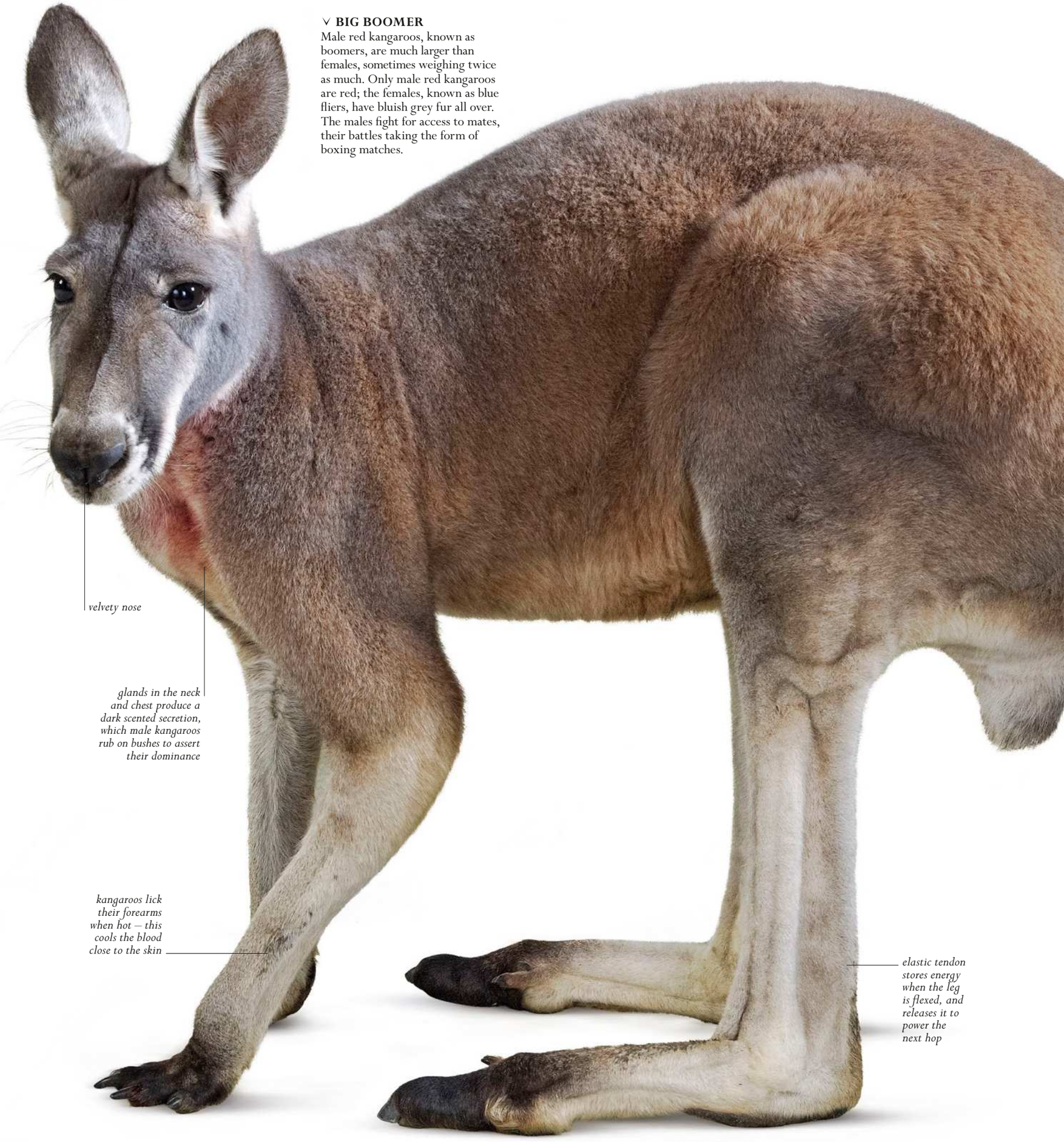
50–85 cm
20–34 in

GOODFELLOW'S TREE KANGAROO
Dendrolagus goodfellowi
Also called the ornate tree-kangaroo, this species is native to the mountainous rainforests of New Guinea, where it feeds on leaves and fruit.

42–71 cm
16½–28 in

LUMHOLTZ'S TREE KANGAROO
Dendrolagus lumholtzi
The smallest of the tree-kangaroos, this marsupial is found in the rainforests of N. Queensland, Australia.

non-prehensile tail


velvety nose
glands in the neck and chest produce a dark scented secretion, which male kangaroos rub on bushes to assert their dominance
kangaroos lick their forearms when hot – this cools the blood close to the skin
elastic tendon stores energy when the leg is flexed, and releases it to power the next hop

BIG BOOMER

Male red kangaroos, known as boomers, are much larger than females, sometimes weighing twice as much. Only male red kangaroos are red; the females, known as blue fliers, have bluish grey fur all over. The males fight for access to mates, their battles taking the form of boxing matches.

RED KANGAROO
Osphranter rufus

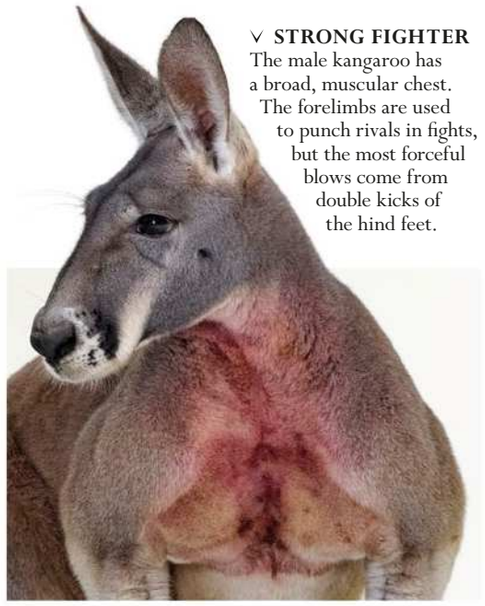
Kangaroos evolved in Australia, filling the niche occupied elsewhere by grazing animals such as antelope. In common with those species, kangaroos have a big stomach to take on large quantities of grass. Living out in the open is risky for all herbivores, and kangaroos share with antelope a number of adaptations for avoiding predators. They live in herds (called mobs), have sharp senses, are tall enough to scan their surroundings for danger, and possess a wonderful turn of speed. The red is the largest and swiftest kangaroo, able to hop at more than 50 km (30 miles) an hour. Only the female has a pouch, in which she carries her young – known as a joey – for the first seven months of its life. Red kangaroos are well adapted to drought – they are able to eat scrubby saltbush, which is toxic to other animals.

SIZE 0.7–1.4 m (2¼–4½ft)
HABITAT Scrubland, desert
DISTRIBUTION Australia
DIET Herbivorous

< EYE
The eyes are widely spaced towards the sides of the head, giving a very wide field of vision. This aids the kangaroo's awareness of predators.

> EARS
The ears are large and sensitive, and can be swivelled in different directions to focus on sounds that might mean danger is approaching.

^ CLAWS
The feet have surprisingly sharp claws. These provide grip when hopping, but also serve as weapons, and as combs for grooming.



v STRONG FIGHTER
The male kangaroo has a broad, muscular chest. The forelimbs are used to punch rivals in fights, but the most forceful blows come from double kicks of the hind feet.

< v HIND FOOT
The scientific name *Macropus* literally means "big foot". Each hind foot has four toes: an outer, weight-bearing pair, and an inner pair used for grooming.

tail acts as a counterbalance when hopping, and as a supportive fifth limb when standing still

^ HOPPING
Red kangaroos hop on their enormous hind legs with apparently effortless grace. They are able to cover up to 9 m (30 ft) in a single bound.

SENGIS

Formerly known as elephant-shrews, sengis form a single family. They are superficially similar to the true shrews, although they are not related.

Distinguished by an elongated, flexible snout, sengis are small, with long legs and tail. They move either on all fours or, especially if they need to move fast, by hopping. Sengis live in pairs within a defined area, although there is little interaction between the partners. Males and females even sometimes make separate nests, each defending the jointly held territory against intruders of its own sex. Active mostly by day, many sengis maintain a network of cleared paths around their territory, which they patrol for prey and use as quick escape routes if threatened.

Found only in Africa, sengis occupy a range of habitats, from forests and savanna to extremely arid deserts. Some take shelter in rock crevices or nests of dried leaves, while the larger species dig out shallow burrows.

Sengis are primarily insectivorous, although some species take spiders and worms. They use their sensitive nose to root on the ground and under leaf litter for food, extending their long tongue to scoop up their prey.

ACTIVE YOUNG

Depending on species, a pair of sengis may breed several times during the year. Litters are small, numbering between one and three young, which are well-developed at birth and rapidly become active.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	MACROSCELIDIDEA
FAMILIES	1
SPECIES	20

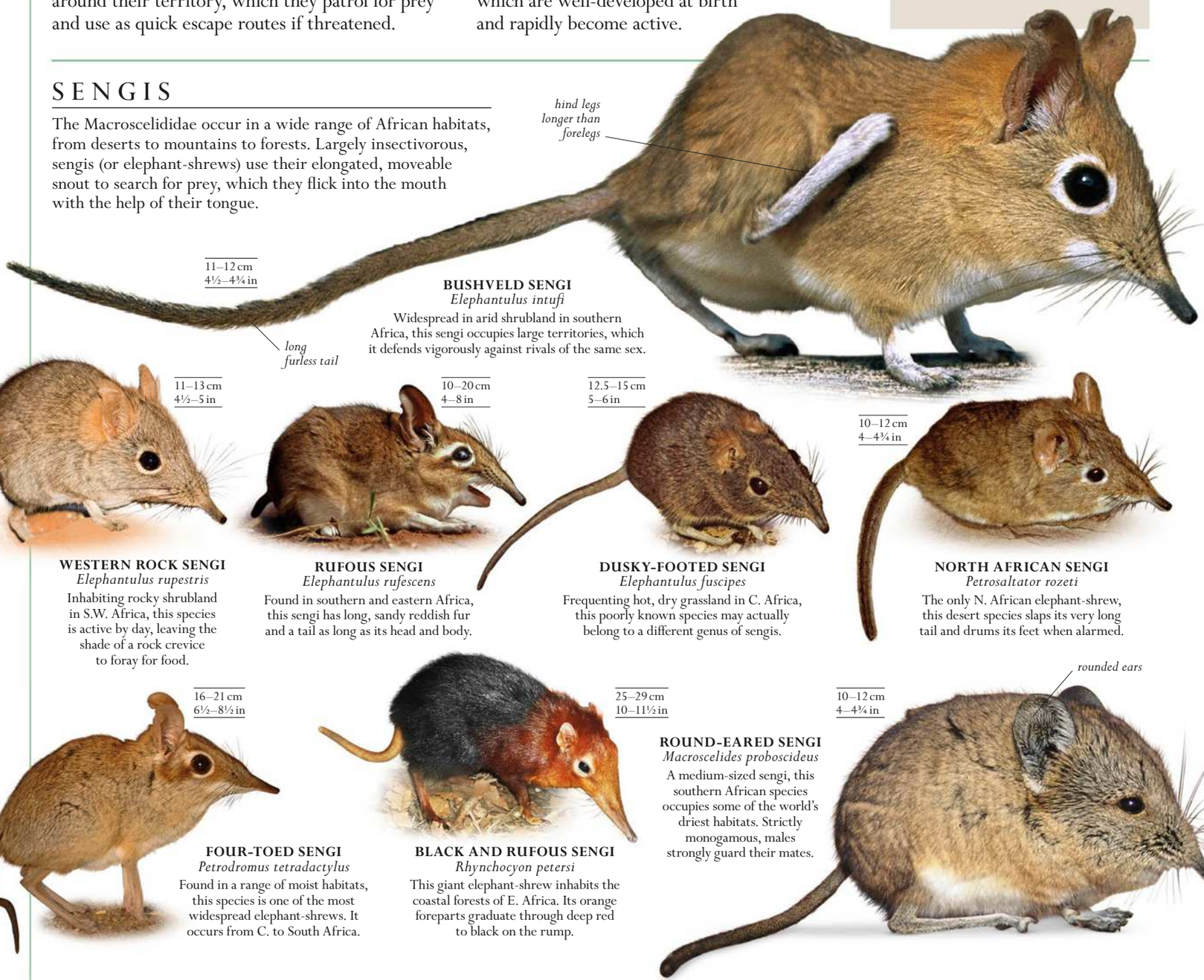
DEBATE

AN ORDER OF THEIR OWN

In the past, sengis have been linked with shrews and hedgehogs, rabbits and pikas, and even ungulates. Now in their own order Macroscelididea, genetic evidence suggests their closest relatives are tenrecs and golden moles in the order Afrosoricida.

SENGIS

The Macroscelididae occur in a wide range of African habitats, from deserts to mountains to forests. Largely insectivorous, sengis (or elephant-shrews) use their elongated, moveable snout to search for prey, which they flick into the mouth with the help of their tongue.



BUSHVELD SENGI
Elephantulus intufi
Widespread in arid shrubland in southern Africa, this sengi occupies large territories, which it defends vigorously against rivals of the same sex.

WESTERN ROCK SENGI
Elephantulus rupestris
Inhabiting rocky shrubland in S.W. Africa, this species is active by day, leaving the shade of a rock crevice to foray for food.

RUFOUS SENGI
Elephantulus rufescens
Found in southern and eastern Africa, this sengi has long, sandy reddish fur and a tail as long as its head and body.

DUSKY-FOOTED SENGI
Elephantulus fuscipes
Frequenting hot, dry grassland in C. Africa, this poorly known species may actually belong to a different genus of sengis.

NORTH AFRICAN SENGI
Petrosaltator rozeti
The only N. African elephant-shrew, this desert species slaps its very long tail and drums its feet when alarmed.

FOUR-TOED SENGI
Petrodromus tetradactylus
Found in a range of moist habitats, this species is one of the most widespread elephant-shrews. It occurs from C. to South Africa.

BLACK AND RUFOUS SENGI
Rhynchocyon petersi
This giant elephant-shrew inhabits the coastal forests of E. Africa. Its orange foreparts graduate through deep red to black on the rump.

ROUND-EARED SENGI
Macroscelides proboscideus
A medium-sized sengi, this southern African species occupies some of the world's driest habitats. Strictly monogamous, males strongly guard their mates.

TENRECS AND GOLDEN MOLES

Three families make up the order Afrosoricidae – the golden moles that are exclusively burrowers, the tenrecs and shrew tenrecs that have evolved into a variety of habitats, and the otter shrews that live in riverine and wetland areas.

Most species in this order are native to mainland Africa, with tenrecs also found in Madagascar. Golden moles are all very similar in appearance, with a cylindrical body and other anatomical adaptations to suit their burrowing lifestyle. In contrast, tenrecs display diverse characteristics that reflect the wide range of environments they occupy. Various species of tenrecs are found in tropical forests, where they may be terrestrial or semi-arboreal. The otter-shrews are aquatic, living in streams and rivers; and there are also burrowing tenrecs. Until recently, tenrecs and golden moles were classified with true moles, shrews, and hedgehogs because of their largely insectivorous diet and often similar appearance. It is now known that the order Afrosoricida evolved independently and is most closely related to the elephants, hyraxes, and sirenians.

UNUSUAL FEATURES

Tenrecs and golden moles have features once considered primitive but now recognized as adaptations to harsh environments. Such features include a low metabolic rate and body temperature. These mammals also have the ability to enter a state of torpor – for up to three days – to save energy in cold conditions, and possess highly efficient kidneys, which reduce the need to drink water.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	AFROSORICIDA
FAMILIES	3
SPECIES	55

A Grant's golden mole feasts on a locust. At night it forages for food on the surface, feeding mainly on termites.

GOLDEN MOLES

These moles resemble both true moles (Talpidae) from Europe, Asia, and North America, and marsupial moles (Notoryctemorphia) from Australia, as all have similar burrowing habits. The Chrysochloridae from southern Africa have short legs with powerful digging claws, dense fur that repels moisture, and toughened skin, especially on the head. They have non-functional eyes covered with skin, and lack external ears.

9–11 cm
3½–4½ in

JULIANA'S GOLDEN MOLE
Neamblysomus julianae
Unique to the dry highlands of South Africa, typically in sandy soils, this species frequents well-irrigated gardens within its range.

soft, dense, glossy fur
webbed toes to kick soil backwards
leathery pad protects nostrils and aids burrowing
eyes covered with thick layer of skin

9–12 cm
3½–4¾ in

CAPE GOLDEN MOLE
Chrysochloris asiatica
Although secretive, this is a common species in parts of South Africa. It uses the enlarged second toe on its front feet for digging.

10–14 cm
4–5½ in

HOTTENTOT GOLDEN MOLE
Amblysomus hottentotus
This golden mole inhabits tunnel systems up to 200 m (655 ft) long, using the large second and third toes on its front feet for digging.

GRANT'S DESERT GOLDEN MOLE
Eremitalpa granti
Inhabiting the southwest African coastal dunes, one of the world's driest habitats, this species "swims" through sand rather than building tunnels.

7.5–8.5 cm
3–3¼ in

TENRECS

From Africa and Madagascar, tenrecs have diverse body forms, resembling the unrelated shrews, mice, hedgehogs, and otters. They range in weight from 5g (3/16 oz) to more than 1 kg (2¼ lb). Largely nocturnal and with poor eyesight, these insectivores use their sensitive whiskers to locate food.

10–18 cm
4–7 in

LOWLAND STREAKED TENREC
Hemicentetes semispinosus
A tail-less tenrec, the coarse, spiny coat of this species is distinctively two-tone – black, with yellow stripes and crown bristles.

18–35 cm
7–14 in

COMMON TENREC
Tenrec ecaudatus
A large terrestrial tenrec, with red-brown fur and spines along the body, the females have up to 29 teats, more than any other mammal.

LESSER HEDGEHOG TENREC
Echinops telfairi
Its hairs modified into spines, this species bears a remarkable resemblance to a true hedgehog, sharing its defence of rolling into a ball.

white-tipped spines on back

10–17 cm
4–6½ in

moderately large ears

sharp claws

10–12 cm
4–4¾ in

RICE TENREC
Oryzorictes sp.
A burrower with well-developed forelimbs, long claws, and small eyes and ears, this tenrec can become very numerous in marshes and rice paddies.

14–23 cm
5½–9 in

GREATER HEDGEHOG TENREC
Setifer setosus
Widespread throughout Madagascar, even in urban habitats, this species has a diverse diet, from insects, earthworms, and carrion to fruit.

AARDVARK

The only species in the Orycteropodidae, the aardvark is adapted for digging. It has an arched back, thick skin, long ears, and a tubular snout.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	TUBULIDENTATA
FAMILIES	1
SPECIES	1

The aardvark's toes (four on the front foot and five on the hind) each have a flattened nail used to dig burrows and excavate insect nests, which it detects through its keen sense of smell.

It uses its long, thin tongue to catch huge numbers of insects. Its teeth are very unusual, and are one of the main reasons for it being classified in its own order. The aardvark is born with incisors and canines at the front of the jaw, but when these fall out they are not replaced. The rear teeth lack enamel, are open-rooted, and grow throughout life.

AARDVARK

Inhabiting savanna and bushland in sub-Saharan Africa, aardvarks are solitary and nocturnal. Powerful front legs with flattened claws are used to dig into the nests of ants and termites for food.

AARDVARK
Orycteropus afer
The yellowish skin of the aardvark is often stained red by soil, in which it burrows and forages. It also has a sparse covering of bristly hairs.

0.9–1.4 m
3–4½ ft

hair lighter coloured on body

long, blunt, shovel-shaped claws

DUGONG AND MANATEES

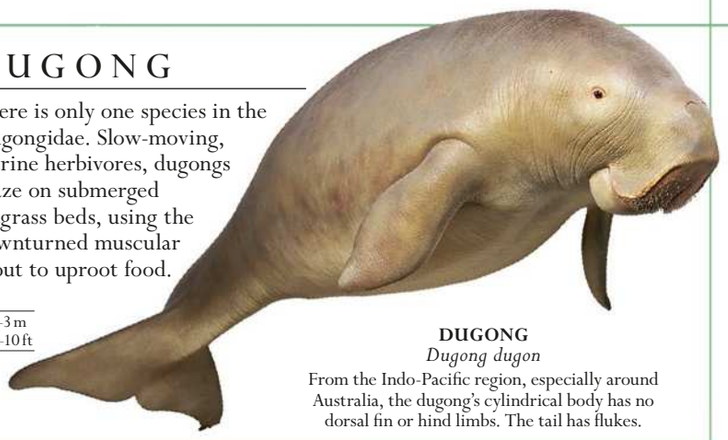
A small order of fully aquatic herbivores, sirenians inhabit a range of tropical habitats, from swamps and rivers to marine wetlands and coastal waters.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	SIRENIA
FAMILIES	2
SPECIES	4

Also known as sea cows, sirenians are supremely adapted to an aquatic way of life. Their front legs are paddle-like and adapted for steering; the hind legs are not visible, being restricted to two small remnant bones floating in the muscle. The body is therefore streamlined, and the flattened tail provides propulsion. A layer of blubber below their skin provides insulation, but to help counteract its natural buoyancy, the bones are dense and the lungs and diaphragm extend for the full length of the spine. The result is a hydrodynamic body, albeit rather slow-moving, capable of fine adjustments to shift its position in the water. All four species are considered to be at risk of extinction.

DUGONG

There is only one species in the Dugongidae. Slow-moving, marine herbivores, dugongs graze on submerged seagrass beds, using the downturned muscular snout to uproot food.



2.5–3 m
8¼–10 ft

DUGONG
Dugong dugon
From the Indo-Pacific region, especially around Australia, the dugong's cylindrical body has no dorsal fin or hind limbs. The tail has flukes.

MANATEES

With a shorter snout than dugongs, the Trichechidae also differ in the shape of their tail, which is paddle-shaped rather than fluked. Rather sluggish, they spend much of the day sleeping under water, surfacing every 20 minutes to breathe.

AMAZONIAN MANATEE
Trichechus inunguis
A freshwater manatee from the Amazon Basin, this species usually has a characteristic white chest patch.

2–3 m
6½–10 ft

2.5–3.9 m
8–12¾ ft

FLORIDA MANATEE
Trichechus manatus latirostris
The largest living sirenian, the Florida manatee inhabits both fresh water and coastal waters of the S.E. USA. It feeds on aquatic plants.

2.5–3.9 m
8–12¾ ft

ANTILLEAN MANATEE
Trichechus manatus manatus
Ranging from Mexico to Brazil, this manatee is smaller and more likely to be found further from the shore than the Florida subspecies.

HYRAXES

Furry and rotund, modern hyraxes belong to the only extant family in the order Hyracoidea. Hyraxes were once the primary terrestrial herbivores in the Old World. Now just five species remain.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	HYRACOIDEA
FAMILIES	1
SPECIES	5

Widely represented in the fossil record of Asia, Africa, and Europe, some extinct species of hyrax were over one metre in height.

Unlike most browsing and grazing animals, hyraxes use their cheek teeth (rather than incisors) to slice vegetation, before chewing it. With a relatively indigestible diet, they have a complex but efficient digestive system in which bacteria break down tough plant matter.

With a number of primitive mammalian features, such as poor control of their internal body temperature, hyraxes show several affinities with elephants: their upper incisor teeth are often extended into short tusks, their soles have sensitive pads, and they have high brain function.

HYRAXES

The Procaviidae are rotund, short-tailed herbivores from Africa and the Middle East. Hyraxes are often seen basking in the sun, and huddling together in groups for warmth. They will also seek shade if too hot. Behaving in this way provides hyraxes with an effective means of thermoregulation.

44–57 cm
17¼–22½ in

long, silky fur

short snout

WESTERN TREE HYRAX
Dendrohyrax dorsalis
A usually dark, semi-arboreal hyrax from W. and C. Africa, this species has a distinctive white patch on its lower back and rump.

32–56 cm
12½–22 in

32–60 cm
12½–23½ in

BUSH HYRAX
Heterohyrax brucei
There are 24 subspecies of bush hyrax in rocky habitats across Africa. It feeds on grass and fruit, and also catches and eats small vertebrates.

39–58 cm
15½–23 in

SOUTHERN TREE HYRAX
Dendrohyrax arboreus
An able climber from southern Africa, usually inhabiting hollow trees, this hyrax is known for its shrieking territorial calls at night.

ROCK HYRAX
Procavia capensis
From Africa and the Middle East, this colonial hyrax basks for long periods. Moist, rubbery foot pads provide grip on smooth rocky surfaces.

^ BRAIN POWER
Long acknowledged for having a good memory, the elephant is now known to solve problems, use tools, show emotions, and work with others, making it one of the most intelligent of all terrestrial animals.

elongated nose and upper lip form the mobile trunk

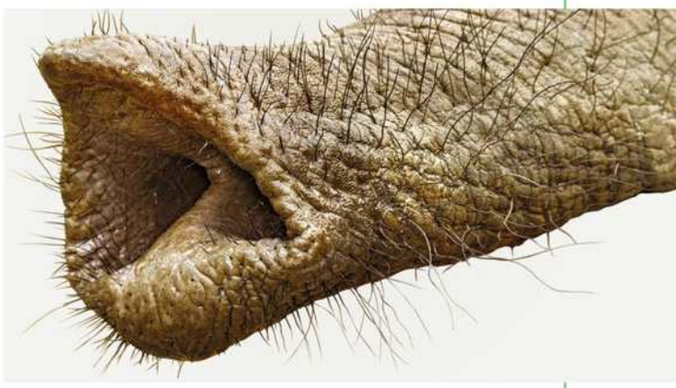
AFRICAN SAVANNA ELEPHANT

Loxodonta africana

A mature male African savanna elephant is larger than any other living land mammal and in exceptional cases can weigh as much as ten tonnes. The head alone can exceed 400 kg (880 lb), including the brain, eyes, trunk, ears, tusks, and teeth. Females are smaller and form strongly bonded herds, comprising a dominant female, close relatives, and their offspring. Bull elephants form less cohesive groups led by older males, but in the breeding season, when they come into musth, they are more solitary and will fight for access to receptive females. Elephants are long lived and may survive well into their 60s.

EYE ∨
Long eyelashes protect the small, laterally-positioned eyes, which can see clearly for only about 10 m (33 ft). Other senses compensate for this limitation.

TRUNK SKIN ∨
The trunk has short sensory hairs along its length that enhance its responsiveness to touch.



EAR >
The large, thin-skinned ears help regulate body temperature. They are also used to communicate moods, such as aggression.

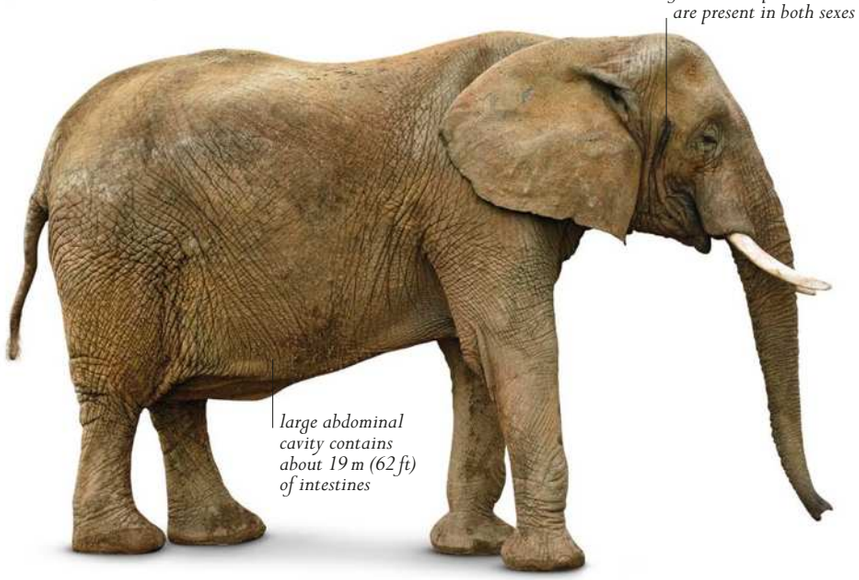
∧ FOOT
Elephant feet have sensory receptors along their margins. They pick up low-frequency underground sounds that can travel over long distances.

∧ FINGER-LIKE TIP
The opposing finger-like projections at the tip of the trunk are extremely sensitive and dextrous. This allows the African savanna elephant to pick up objects as small as a peanut.

< TAIL
Elephants swing their tail to deter insects. The air turbulence created prevents them from landing, and any that do are swatted.

the tusks are enlarged second incisor teeth

musth glands are only found in elephants and are present in both sexes



large abdominal cavity contains about 19 m (62 ft) of intestines

SIZE 2.6–4 m (8½–13 ft)
HABITAT Dry woodland, scrub, and savanna grassland
DISTRIBUTION Mainly E. and S. Africa, south of the Sahara
DIET Leaves, roots, bark, fruits, and seeds

LARGE AND HEAVY >
A bulky body supported by rather straight, columnar legs might suggest the elephant is a slow-moving animal. It can, however, reach speeds of 24kph (15mph) when charging.

ELEPHANTS

Largest of all land mammals, elephants are distinguished by their colossal bulk, long flexible trunk, large ears, and curving ivory tusks.

The only members of the Proboscidea, elephants inhabit grassland and forest in tropical Africa and Asia. Sometimes weighing more than five tonnes, elephants have a modified skeleton to bear their weight. The limb bones are extremely stout, and the toes are splayed around a pad of connective tissue. This large frame needs vast amounts of food and elephants eat for up to 16 hours a day, consuming up to 250 kg (550 lb) of vegetation.

EARS, NOSE, AND MOUTH

The elephant's muscular trunk, a fusion of the nose and upper lip, is remarkably versatile and is able to grasp morsels of food. It can also draw in water and serve as a snorkel when swimming. Sensory organs in the trunk pick up scents and vibrations, so aiding communication. An elephant's large ears are also used for communication and when spread out are a sign of aggression. However, constant flapping helps an elephant to lose heat. Tusks are incisor teeth that grow continually. They are used to dig for roots and salt, clear pathways, and mark territories.

SOCIAL STRUCTURES

Male and female elephants have different social behaviour. Females form herds of related cows and their calves, led by an elderly matriarch. Bull elephants form short-term associations, but will fight with any intruding rival during the breeding season.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PROBOSCIDEA
FAMILIES	1
SPECIES	3

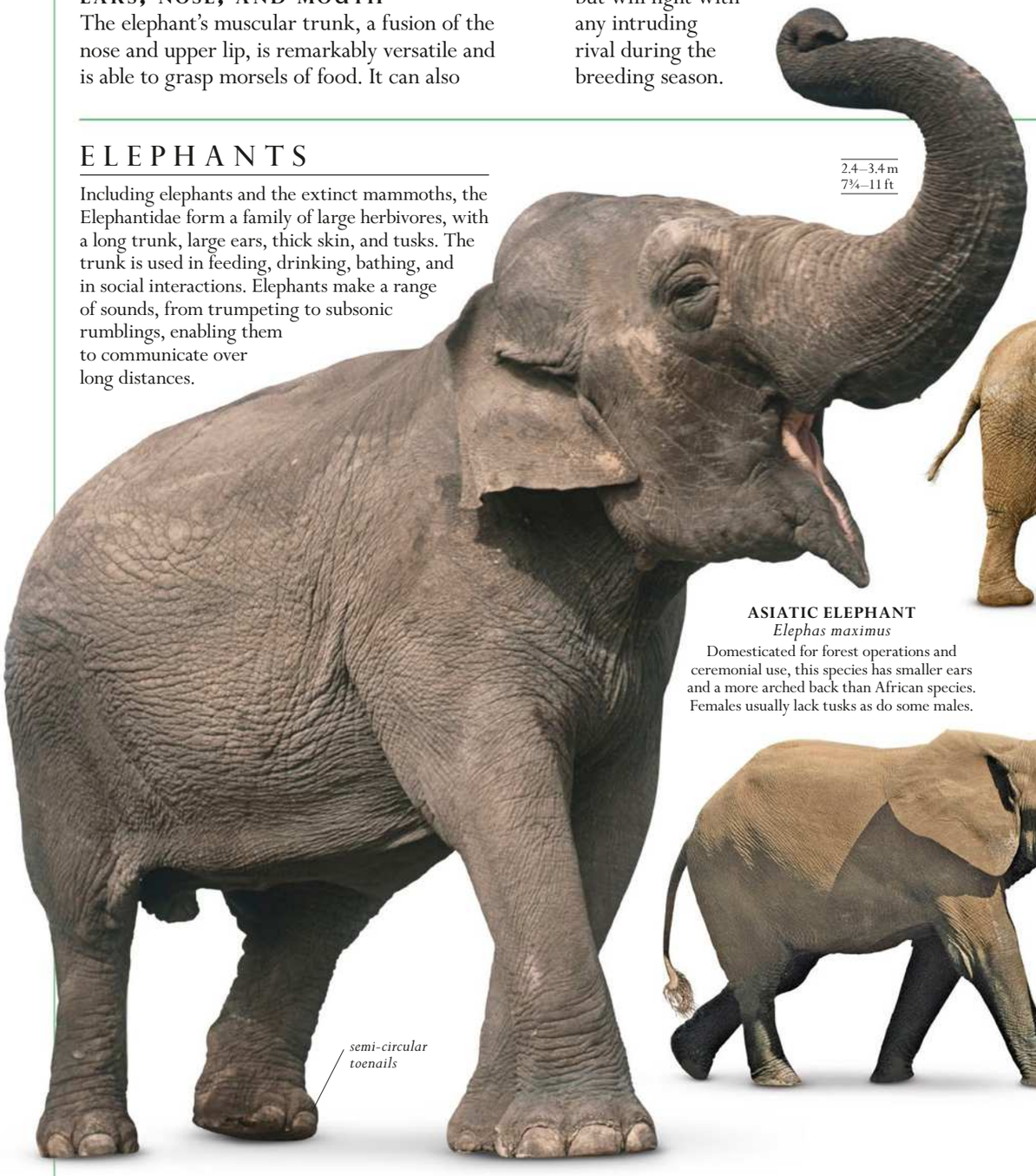
DEBATE

TWO SPECIES OR ONE?

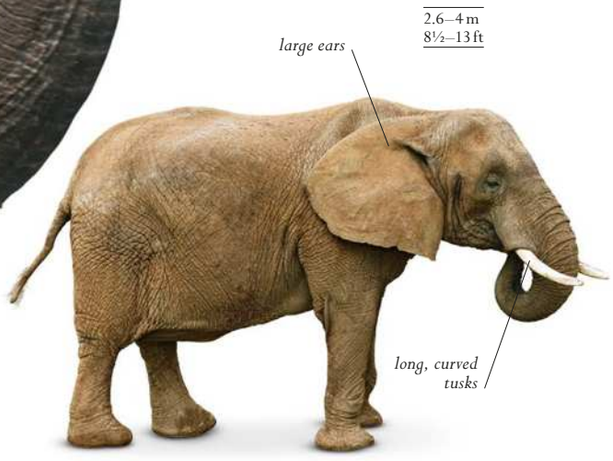
The splitting of the African elephant into two species, the savanna elephant and the smaller forest elephant, was originally based on physical differences, but now there is sufficient genetic evidence to substantiate this division. However, some scientists are reluctant to accept this idea because the two species sometimes interbreed where their ranges overlap.

ELEPHANTS

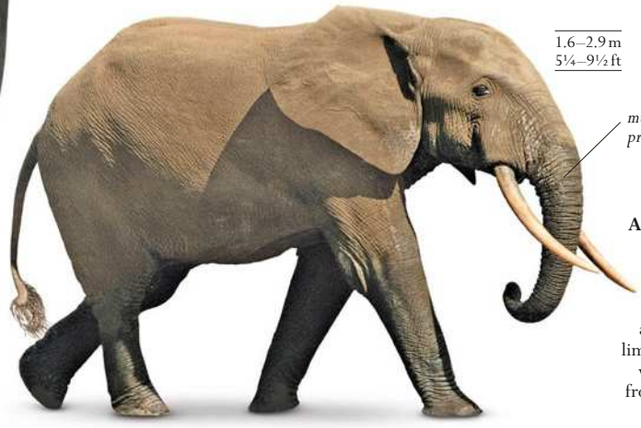
Including elephants and the extinct mammoths, the Elephantidae form a family of large herbivores, with a long trunk, large ears, thick skin, and tusks. The trunk is used in feeding, drinking, bathing, and in social interactions. Elephants make a range of sounds, from trumpeting to subsonic rumblings, enabling them to communicate over long distances.



ASIATIC ELEPHANT
Elephas maximus
Domesticated for forest operations and ceremonial use, this species has smaller ears and a more arched back than African species. Females usually lack tusks as do some males.



AFRICAN SAVANNA ELEPHANT
Loxodonta africana
The largest living land animal, this elephant has a large head and ears. Both sexes have well-developed, curved tusks.



AFRICAN FOREST ELEPHANT
Loxodonta cyclotis
With five toenails on the forelimbs and four on the hind limbs, this small elephant with straight tusks is from the tropical forests of Central Africa.

ARMADILLOS

Recognizable by their armoured shell – unique among mammals – armadillos occur in various shapes, sizes, and colours. All are native to the Americas.

Armadillos, sole members of the order Cingulata, range across a variety of habitats, feeding mostly on insects and other invertebrates. Despite having short legs, armadillos can run quickly and burrow with their strong claws to avoid predators. Their main defence consists of a bony carapace, covered with horny plates, across their upperparts. In most species, there are rigid shields over the shoulders and hips, with a varying number of bands separated by flexible skin covering the back and flanks. This allows some species to roll into a ball to protect their vulnerable, furry underparts.

Armadillos have few natural predators. Despite the threats from human hunters and habitat loss, the range of some armadillo species is expanding.

Although their armour is heavy, armadillos are effective swimmers. By inflating the stomach and intestines with air, they can increase their buoyancy and cross small bodies of water. Armadillos can hold their breath under water for several minutes, allowing them to walk over a stream bed rather than swim across it.

HABITS

Most species of armadillo are nocturnal, though they occasionally emerge during the day as well. These animals are largely solitary, associating with one another only during the mating season. Males sometimes display aggression towards rivals.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CINGULATA
FAMILIES	2
SPECIES	20

Contrary to popular belief, not all armadillos can roll into a ball in defence – only species of the genus *Tolypeutes* can.

ARMADILLOS

The only surviving family in their order, the Dasypodidae are found in the Americas. Covered with bony plates across their upperparts, they use their sharp claws to dig for invertebrates and to excavate burrows. Of the 20 or so species, some are able to roll into a ball when threatened, in order to protect their vulnerable, soft, furry underparts.

LONG-NOSED ARMADILLO
Dasypus sp.
The seven species of this genus inhabit shaded, rocky areas. Unlike other armadillos, they have sparse, yellowish fur, mainly on their bellies.

ANDEAN HAIRY ARMADILLO
Chaetophractus vellerosus
Unusual in having copious hair between its scales, this mammal inhabits high-altitude S. American grasslands. It is hunted for its meat and shell.

LARGE HAIRY ARMADILLO
Chaetophractus villosus
From arid habitats in southern S. America, this species has long, coarse hairs between the 18 or so plates of protective armour across its back.

PICHI
Zaedyus pichiy
A small, dark armadillo with thick dorsal plates, this species wedges itself into its burrow when threatened, presenting its jagged scales for defence.

SIX-BANDED ARMADILLO
Euphractus sexcinctus
More active by day than most armadillos, this brownish-yellow species forages in grassland and forest, eating plant and animal matter.

PINK FAIRY ARMADILLO
Chlamyphorus truncatus
This tiny armadillo from C. Argentina is mainly subterranean, "swimming" through loose sand; its head is shielded to reduce abrasion.

NORTHERN NAKED-TAILED ARMADILLO
Cabassous centralis
The protective plates of this C. and S. American armadillo do not extend to its tail. It relies mainly on dense cover to avoid predators.

GIANT ARMADILLO
Priodontes maximus
The largest armadillo, this species has tough armour and uses its long, curved third front claw to dig for food and in defence.

SIX-BANDED ARMADILLO

Euphractus sexcinctus

Despite its name, this species of armadillo may have anything from six to eight armoured bands around its middle. The upper part of the animal's body is covered by a sturdy carapace. The carapace is made up of plates of bone, topped with a thin covering of horny material, and it is embedded in the armadillo's skin. The bands act as joints in the carapace, giving the animal flexibility, although it is unable to curl completely into a ball like some other species. The six-banded armadillo is diurnal, spending the daylight hours trundling about its home range in search of food. It has a varied diet, ranging from roots and shoots to invertebrates and carrion.

SIZE 40–50 cm (16–20 in)
HABITAT Forest and savanna
DISTRIBUTION S. America, mainly south of Amazon Basin
DIET Omnivorous

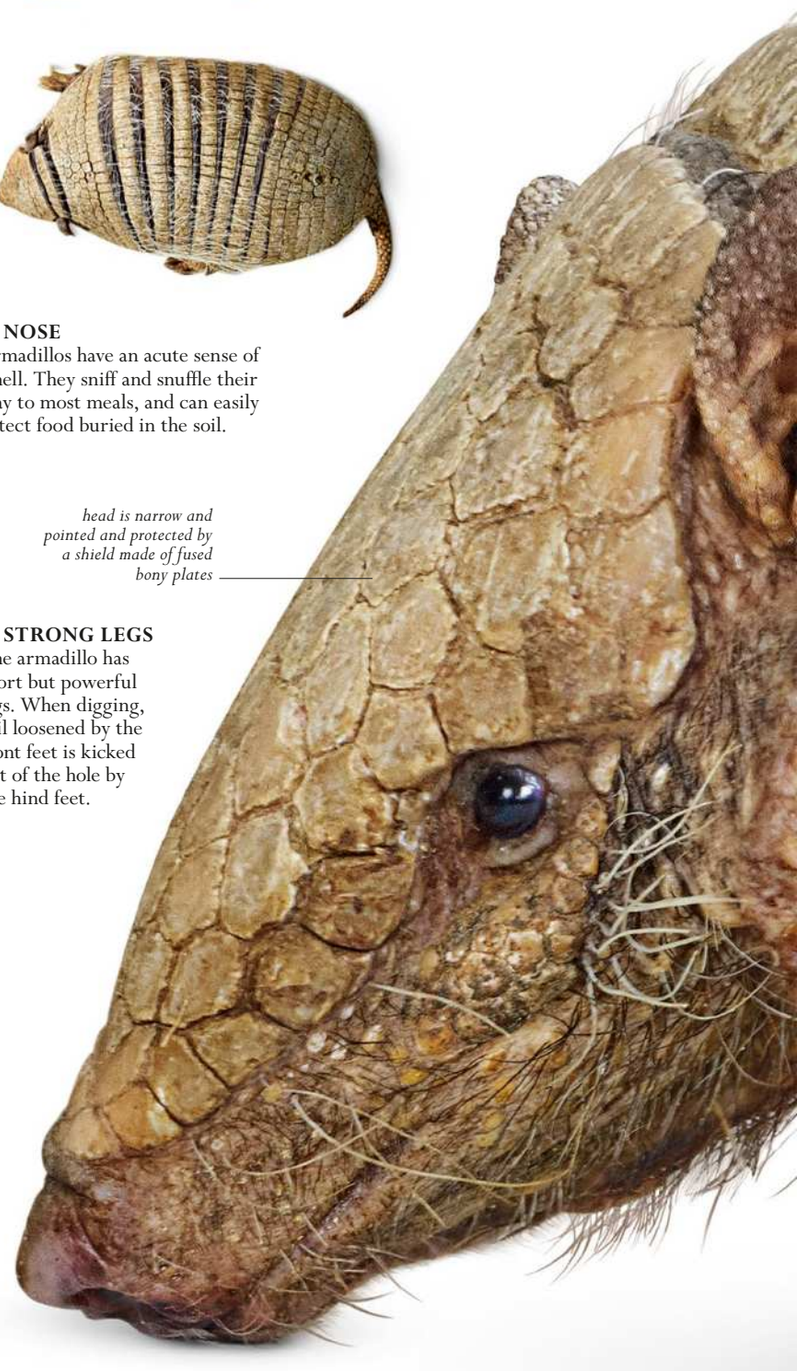
< SHIELDED EYE
The armadillo's eyes are protected by the headshield at the expense of a slightly restricted field of vision. As it has poor eyesight anyway, this makes little difference.

< NOSE
Armadillos have an acute sense of smell. They sniff and snuffle their way to most meals, and can easily detect food buried in the soil.

^ HAIRY SKIN
The bony carapace is interrupted by six to eight bands, which are separated by flexible skin. Long, bristly hairs sprout from between the bands – this is one of the hairy armadillos.

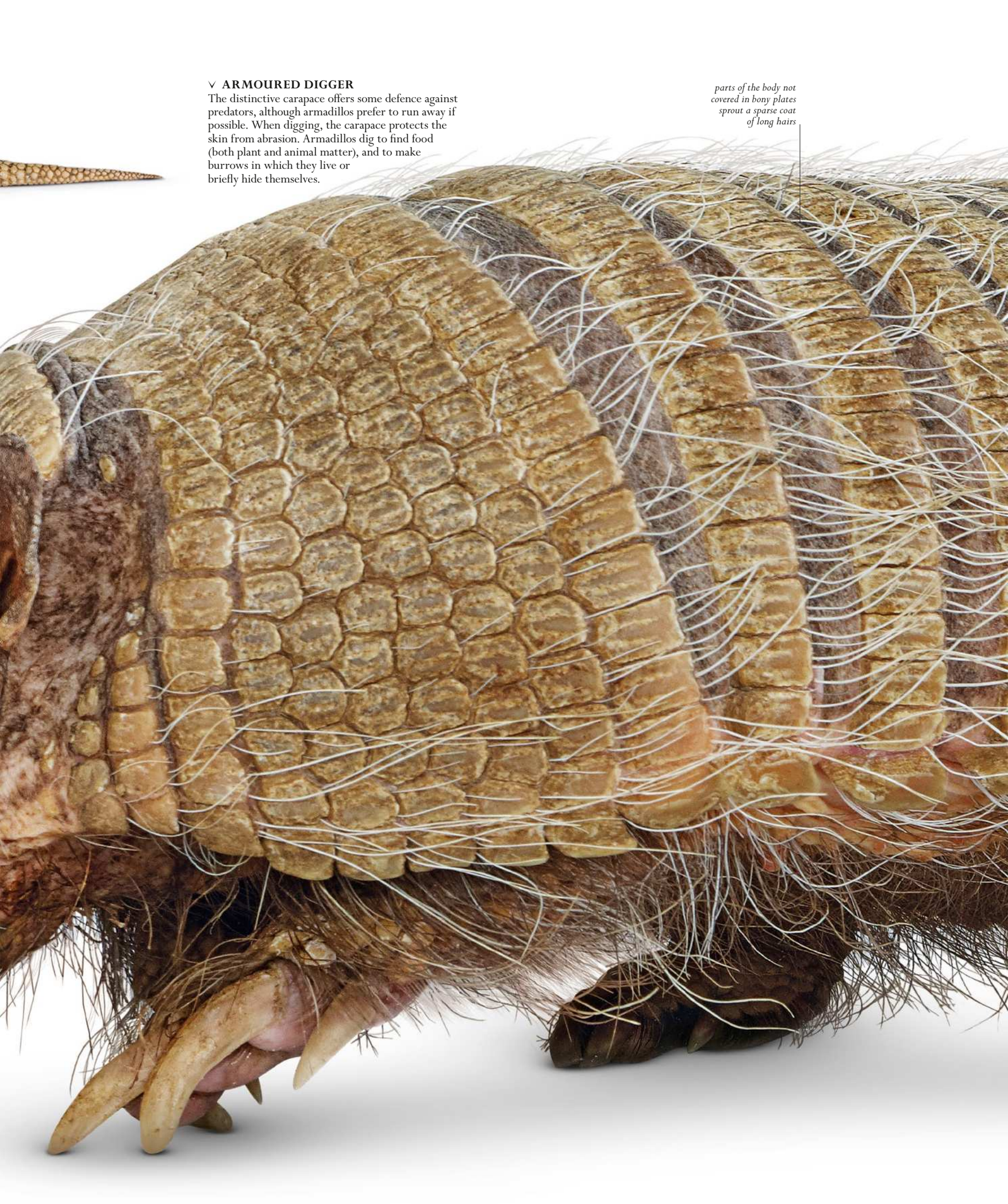
TAIL >
Glands at the base of the armadillo's tail release scent through small holes in the armour plates. The scent marks the armadillo's territory.

^ CLAWS
Long, strong claws allow the armadillo to dig rapidly into hard ground. In a matter of minutes it is able to excavate a trench deep enough to bury itself in.



head is narrow and pointed and protected by a shield made of fused bony plates

< STRONG LEGS
The armadillo has short but powerful legs. When digging, soil loosened by the front feet is kicked out of the hole by the hind feet.



ARMOURED DIGGER

The distinctive carapace offers some defence against predators, although armadillos prefer to run away if possible. When digging, the carapace protects the skin from abrasion. Armadillos dig to find food (both plant and animal matter), and to make burrows in which they live or briefly hide themselves.

SLOTHS AND ANTEATERS

Although very different in form and habits, sloths and anteaters have one characteristic in common: they share a lack of normal mammalian dentition.

With just one exception, members of this order, the Pilosa, are largely arboreal creatures: only the giant anteater is terrestrial. They are all native to Central and South America.

The two anteater families feed on ants, termites, and other insects. Anteaters have no teeth at all, relying on their long sticky tongue to capture insects, which are then crushed in the mouth before being swallowed.

The slow-moving sloths are herbivorous. They have no incisors or canines, but instead have a number of cylindrical, rootless teeth, used to grind up their food. A sloth may take about a month to completely digest a meal, as the fibrous leaf matter passes slowly through several stomach compartments and is broken down by bacteria.

ARBOREAL LIFE

The long, prehensile tail of the arboreal anteaters allows them to lead a more active lifestyle than the sloths. On the ground, all the arboreal species move only with difficulty, although some are excellent swimmers. When walking, their mobility is restricted by their enlarged, curved claws, which the sloths use like hooks to hang from branches. Anteaters have enlarged claws only on their front feet. These claws are used to tear open insect nests in search of food, and are formidable defence weapons.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PILOSA
FAMILIES	4
SPECIES	16

To defend themselves members of the genus *Tamandua* stand up on their hind legs and lash out with their powerful front limbs.

THREE-TOED SLOTHS

Generally smaller and slower moving than two-toed sloths, the arboreal and mostly nocturnal Bradypodidae have three toes on each foot, bearing long, curved claws that help them to hang from branches. Their long, shaggy fur has a green tinge, due to algae growing on it.

59–72 cm
23–28 in

MANED SLOTH
Bradypus torquatus
This small Brazilian sloth has long, dark fur – especially around its head and neck – which often harbours algae, ticks, and moths.

BROWN-THROATED SLOTH
Bradypus variegatus
An inhabitant of the forests of C. and S. America, this sloth is the most widespread in its family. The female attracts her mate with a shrill scream.

52–54 cm
20½–21½ in

45–76 cm
18–30 in

shaggy, coarse coat

PALE-THROATED SLOTH
Bradypus tridactylus
Found in the rainforests of S. America, this species usually lives alone and may rest for more than 18 hours a day.

TWO-TOED SLOTHS

Unlike three-toed sloths, the Megalonychidae have only two toes on their forefeet, a more prominent snout, and no tail. Similarly arboreal and mainly nocturnal, they usually descend from trees head first.

54–88 cm
21½–35 in

two toes on front feet

54–88 cm
21½–35 in

SOUTHERN TWO-TOED SLOTH
Choloepus didactylus
This large herbivore from S. America swims well, even crossing rivers. Its main predators are large raptors, such as harpy eagles.

54–88 cm
21½–35 in

LINNAEUS'S TWO-TOED SLOTH
Choloepus hoffmanni
This solitary, S. American herbivore is found in the tropical forests of the Orinoco and Amazon river basins, where it spends most of its time sleeping or resting in the forest canopy.

SILKY ANTEATERS

The Cyclopedidae, though well-represented in the fossil record, has seven extant species. Large, curved front claws and a prehensile tail help silky anteaters live on trees, where they nest in holes. They feed on ants and termites.

SILKY ANTEATER
Cyclopes sp.
Arboreal, nocturnal, and slow moving, silky anteaters live in forested areas of Central and South America. Their claws provide an effective defence when threatened by predators.

19–22 cm
7½–9 in

GIANT ANTEATER AND RELATIVES

Native to Central and South America, the Myrmecophagidae have an elongated snout and a long tongue. They use their powerful claws to rip open termite mounds and ant hills. Lacking teeth, they catch insects with their sticky saliva and spine-covered tongue.

47–77 cm
18½–30 in

SOUTHERN TAMANDUA
Tamandua tetradactyla
This solitary species has a prehensile tail. It forages for food at any time of day, and is active for about 7 hours in every 24.

1–1.4 m
3¼–4½ ft

GIANT ANTEATER
Myrmecophaga tridactyla
The largest anteater, with a tail almost as long as its body, this species uses its long, sticky tongue to catch up to 30,000 insects a day.

RABBITS, HARES, AND PIKAS

Two herbivorous families make up the order known as Lagomorpha. Their apparent similarities to rodents result from adaptation to a common lifestyle.

These species occupy a variety of habitats, from tropical forest to Arctic tundra. All are terrestrial herbivores or browsers. They are gnawing animals and share the diet of many rodents. Like those of rodents, the teeth of rabbits, hares, and pikas continue to grow throughout life – they are worn down by chewing. However, there are fundamental differences between the groups: rabbits and their relatives have four incisors in the upper jaw, while rodents have only two.

Relying on food that is relatively slow to break down, these animals have a modified digestive system. They produce two types of faeces: moist pellets, which are eaten to gain further nutrients from the food, and dry pellets passed as waste.

ESCAPING PREDATORS

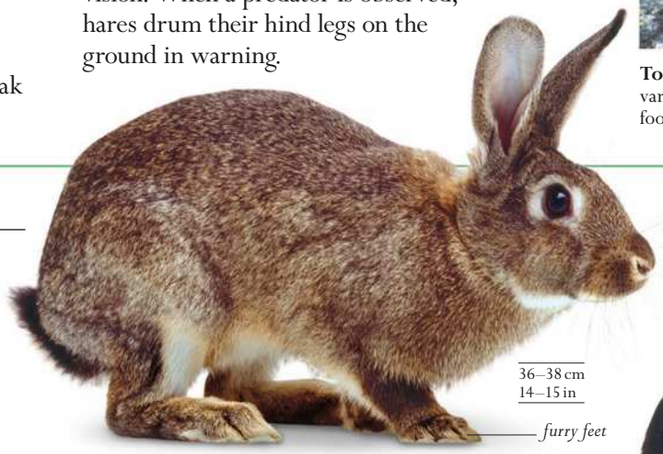
Pikas, the most rodent-like species in this order, take refuge from predators in burrows and crevices after raising the alarm with a whistle. Rabbits and hares, in contrast, have long ears to detect danger and powerful limbs to flee from predators. These animals have large eyes positioned high on each side of the head to provide almost 360-degree vision. When a predator is observed, hares drum their hind legs on the ground in warning.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	LAGOMORPHA
FAMILIES	2
SPECIES	OVER 90

To survive the winter, the pika collects various plants, creates a hay pile of dried food, and stores it in its den.

RABBITS AND HARES

Native across much of the world, the Leporidae have long, movable ears and enlarged hind legs to detect and escape predators. Large eyes reflect their mainly nocturnal habits. Rabbits often inhabit permanent burrow systems, whereas the more solitary hares make only transitory shelters.



36–38 cm
14–15 in

EUROPEAN RABBIT
Oryctolagus cuniculus
Native to the Iberian penninsula, this species has been introduced for meat and fur worldwide, with devastating effects on local habitats and wildlife.

13–18 cm
5–7 in

DWARF RABBIT
Oryctolagus cuniculus
One of the smallest breeds, the dwarf rabbit occurs in many colours and patterns. Its rounded face and small ears make it a popular pet.

25–38 cm
10–15 in

ANGORA RABBIT
Oryctolagus cuniculus
Valued for its long, soft hair, which is spun into yarn, this breed originates from Anatolia (in modern-day Turkey).

15–30 cm
6–12 in

LOP-EARED RABBIT
Oryctolagus cuniculus
First bred in England in the 19th century, this type has long, lop-eared (floppy) ears. There is variation in both colour and size.

hairs of the coat are long, coarse, and grooved and grow away from the belly
strong, elongated fore- and hind limbs are about the same length

TOPSY-TURVY WORLD > Adapted to living upside down in the forest canopy, Linnaeus's two-toed sloth rarely ventures to the forest floor other than to relieve itself every 3–5 days. Strong fingers with claw-like hooks for grasping branches allow it to eat, mate, give birth, and even sleep in this position.

LINNAEUS'S TWO-TOED SLOTH

Choloepus hoffmanni

Small and arboreal, Linnaeus's two-toed sloth is far removed from its giant ground-dwelling ancestors, which only became extinct about 10,000 years ago. It is one of the slowest-moving mammals and sleeps for about 13 hours a day, often curled into a ball in the fork of a tree, waking at night to forage for leaves. The sloth's fur is unusual in supporting an ecosystem that includes unique micro-organisms, green algae, and various insects. In damp conditions, the coat may acquire a green hue due to the algae growing in the grooves of the hairs.

SIZE 54–88 cm (21½–35 in)
HABITAT Tropical lowland forest
DISTRIBUTION Orinoco and Amazon basins, S. America
DIET Mainly leaves

EYE >
The eyes are large and forward facing, but the eyesight is poor. Sloths are near-sighted, colour blind, and have poor visual acuity.

< TEETH
The five upper and four lower teeth are peg-like, lack enamel, and grow throughout life. There are no incisors.

NOSE >
A short snout with a large, snub nose at its tip provides the sloth with an excellent sense of smell.

< EAR
The sloth's hearing is poor and limited to lower frequencies. The external part of the ear is tiny and buried in the fur.

CLAWS v >
The forelimb terminates in two digits, each with a 8–10 cm (3¼–4 in), hook-like claw. The hind limb has three clawed digits.

MIDDLE PARTING >
Due to their upside-down lifestyle, the fur parts in the midline of the chest and abdomen and falls down towards the back, so rain will run off.

37–40 cm
14½–16 in

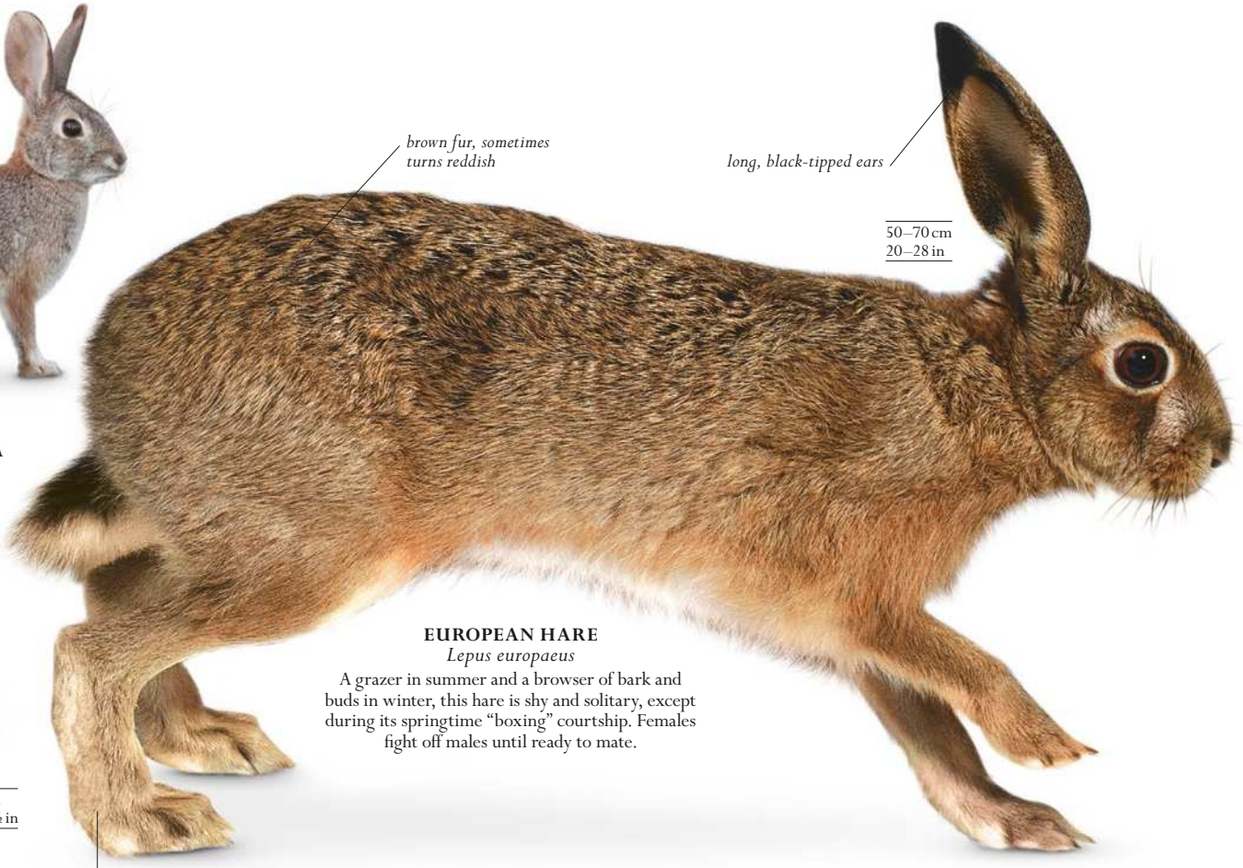
DESERT COTTONTAIL
Sylvilagus audubonii
Found in arid regions of S.W. USA and N. and C. Mexico, the desert cottontail nests above ground rather than in a burrow.

MARSH RABBIT
Sylvilagus palustris
42–44 cm
16½–17½ in
Inhabiting wetlands of N. America, this species is a strong swimmer. It walks instead of hopping, unlike most of its relatives.

brown fur, sometimes turns reddish

long, black-tipped ears

50–70 cm
20–28 in



EUROPEAN HARE
Lepus europaeus
A grazer in summer and a browser of bark and buds in winter, this hare is shy and solitary, except during its springtime "boxing" courtship. Females fight off males until ready to mate.

powerful hind legs

36–52 cm
14–20½ in

SNOWSHOE HARE
Lepus americanus
Adapted to harsh N. American winters, this species has a white winter coat for camouflage, and large hind feet to allow movement on soft snow.

55–70 cm
22–28 in

ARCTIC HARE
Lepus arcticus
Adapted to polar and mountainous areas, this hare survives with thick fur that turns white in winter, and by digging snow holes for shelter.

56–66 cm
22–26 in

WHITE-TAILED JACKRABBIT
Lepus townsendii
This species ranges extensively across western N. America. The northern population turns white in winter, while the southern animals develop whitish patches only on their flanks.

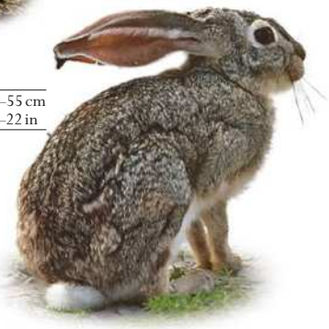
55–67 cm
22–26 in

ANTELOPE JACKRABBIT
Lepus alleni
Very long ears and insulated, reflective fur help this large hare to keep cool in its desert grassland habitats in Mexico.

51–55 cm
20–22 in

MOUNTAIN HARE
Lepus timidus
From polar regions and mountains in Europe and Asia, this hare has a white winter coat and a tail that stays white all year round.

45–55 cm
18–22 in



CAPE HARE
Lepus capensis
Common in open habitats of Africa and the Middle East, this species is very similar to the closely related European hare.

52–61 cm
20½–24 in

BLACK-TAILED JACKRABBIT
Lepus californicus
Widespread on western N. American prairies and farmland, this species is prone to huge local fluctuations. It has a black tail and black ear-tips.

long legs

PIKAS

The Ochotonidae are small herbivores that live in rocky mountain sides and open steppes in North America and Asia. Alert to predators, they produce high-pitched alarm calls as they run for cover in crevices and burrows.

16–21 cm
6½–8½ in

AMERICAN PIKA
Ochotona princeps
This N. American montane scree dweller dries food piles in the sun, and stores them in its den for the winter.

RODENTS

Ranging from tiny mice to animals the size of a pig, rodents live in almost every habitat type. They make up nearly half of all mammal species.

Members of the order Rodentia are distinguished by having a pair of prominent upper and lower incisor teeth (often orange or yellow in colour), which continue to grow throughout life. Gnawing – a characteristic behaviour of all rodents – wears the teeth away at the same rate as they grow. Rodents have no canine teeth, just a long space between the incisors and the three or four cheek teeth in each jaw. The scientific classification of rodents is also based on other features of their teeth and jaws that are not visible externally.

SPECIES DIVERSITY

To suit their various lifestyles, rodents often have special adaptations such as webbed toes, big ears, or long hind feet for a bounding gait. Some rodents burrow, others live in trees or in the water, but none live in the sea. Many species inhabit desert regions, where they may never drink, deriving all the water they need from food.

THE IMPACT OF RODENTS

Several rodent species carry fatal diseases that have killed millions of people. Others consume or contaminate huge quantities of stored food meant for humans. The house mouse has become the world's most widespread wild mammal through its close association with humans. This species inhabits every continent, except Antarctica, even surviving in mines and cold stores. Some rodents cause damage to crops or trees, or burrow in inconvenient places. Beavers can transform entire habitats, affecting hundreds of other animal and plant species.

On the positive side, rodents are a vital food source for predatory animals and, in some countries, for humans as well. Many small rodents, such as hamsters, are specially bred as pets.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	RODENTIA
FAMILIES	34
SPECIES	About 2,500

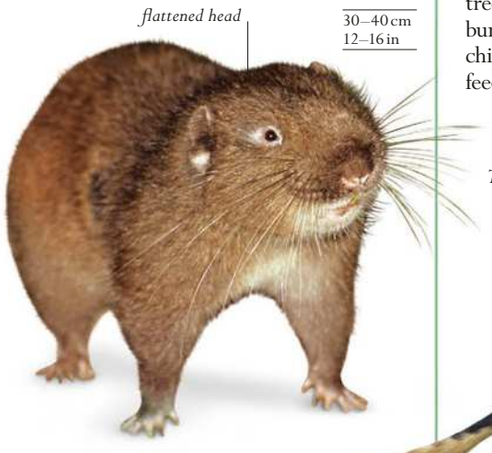
DEBATE

RODENT ORGANIZATION

The huge diversity of species in the order Rodentia makes the task of classifying them rather complicated. With 34 families of modern rodent to organize, experts in zoological classification have divided them into two subgroups, according to differences in their skulls, teeth, and jaws. The Sciurognathi (squirrel-jaws) are globally widespread, and include all squirrels, beavers, and mouse-like rodents. The Hystricognathi (porcupine-jaws) includes the cavies, porcupines, chinchillas, and the capybara, and these are mostly restricted to the southern hemisphere and the tropics.

MOUNTAIN BEAVER

Only one species of the once widespread family Aplodontiidae has survived into modern times. The mountain beaver, or sewellel, lives in burrows in the damp forests and plantations of western North America.



MOUNTAIN BEAVER
Aplodontia rufa
This most primitive type of living rodent inhabits forested coastal mountains of W. Canada and the USA.

SQUIRRELS AND CHIPMUNKS

Occurring almost everywhere, except in the polar regions, Australia, and the Sahara Desert, members of the family Sciuridae range from tropical rainforests to Arctic tundra, and from the tops of trees to underground tunnels. This family includes typical bushy-tailed tree squirrels, many species of burrow-digging ground squirrels, chipmunks, and marmots. They feed mainly on nuts and seeds.

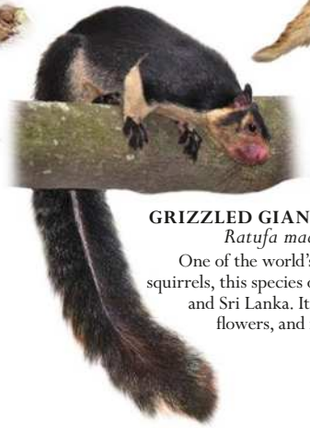
GREY SQUIRREL
Sciurus carolinensis
Common in the E. USA, this species was introduced to parts of Europe, where it is slowly displacing the native red squirrel.

EURASIAN RED SQUIRREL
Sciurus vulgaris
When this squirrel moults into its summer coat, the long hairs on its ears are lost.

AMERICAN RED SQUIRREL
Tamiasciurus hudsonicus
The chattering calls and sharp barks of this red squirrel are common sounds of coniferous woodlands in Canada and the N. USA.

SOUTHERN FLYING SQUIRREL
Glaucomys volans
A strictly nocturnal native of the eastern USA, this squirrel lives in tree holes and attics, often in groups during winter.

PALE GIANT SQUIRREL
Ratufa affinis
Of the four species of giant squirrel, this species inhabits the forests of the Malay Peninsula, Borneo, and Sumatra.



GRIZZLED GIANT SQUIRREL
Ratufa macroura
One of the world's largest tree squirrels, this species occurs in S. India and Sri Lanka. It eats fruits, flowers, and insects.

PREVOST'S SQUIRREL
Callosciurus prevostii
There are 17 subspecies of these tricoloured squirrels. Prevost's is found in Malaysia, Borneo, Sumatra, and nearby islands, such as Sulawesi.

»

» SQUIRRELS AND CHIPMUNKS

17–27 cm
6½–10½ in

GAMBIAN SUN SQUIRREL
Heliosciurus gambianus
A common species in savanna woodlands across Africa, from Senegal to Zimbabwe, this squirrel feeds mainly on the seeds of Acacia trees.

long, bushy tail

CAPE GROUND SQUIRREL
Geosciurus inauris
This coarsely haired squirrel escapes the extreme temperatures of the semi-deserts of South Africa by sheltering in burrows.

15–20 cm
6–8 in

COLUMBIAN GROUND SQUIRREL
Urocitellus columbianus
A rather large, bushy tailed ground squirrel, this species forms colonies in meadows and forest edges from Idaho, USA, north into W. Canada.

25–30 cm
10–12 in

GOLDEN-MANTLED GROUND SQUIRREL
Callospermophilus lateralis
Appearing like a larger version of the chipmunk, this species is a common sight in forests and mountains of the W. USA.

22–28 cm
9–11 in

12–15 cm
4¾–6 in

HOPI CHIPMUNK
Tamias rufus
Chipmunks from different parts of N. America form separate species. This species occurs in Utah, Colorado, and adjacent parts of Arizona.

12–15 cm
4¾–6 in

short hairy tail

EASTERN CHIPMUNK
Tamias striatus
This striped, ground-living species is a common sight in forest campgrounds of the E. USA, where it has become quite tame.

BEAVERS

There are only two species of beavers in the family Castoridae. Both are exploited for their fur. One is widespread across North America, and the other in patches throughout most of Europe. Both build dams out of stones, mud, and trees, creating habitats for other species.

BEAVER
Castor sp.
European and N. American beavers are different species, but both live a similar, semi-aquatic life in rivers and lakes.

glossy, brown fur

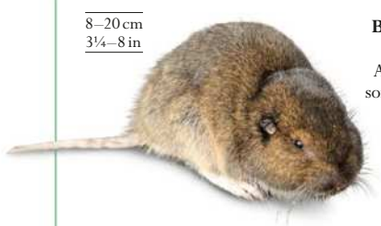
0.8–1.2 m
2½–4 ft

flat, scaly tail

GOPHERS

Members of the family Geomyidae, found in North America, live alone in shallow burrows that allow them to access roots and leaves. They carry their food in cheek pouches and store it in underground chambers.

8–20 cm
3¼–8 in



BOTTA'S POCKET GOPHER
Thomomys bottae
A small burrowing creature of soft soil and grassy areas, this species digs up mounds of earth, which can damage farm machinery.

DORMICE

The Gliridae occur in wooded habitats across Europe, sub-Saharan Africa, and patchily in Central Asia, with a single species in Japan. Resembling small nocturnal squirrels, all but one are soft-furred, arboreal species. Many are threatened or are declining in numbers.

AFRICAN DORMOUSE
Graphiurus sp.
There are 15 species of African dormice. They are all similar in appearance and inhabit forested areas of sub-Saharan Africa.

bushy tail

7–15 cm
2¾–6 in

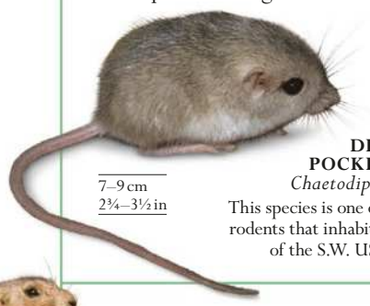
MARMOT
Marmota sp.
Several species of marmots inhabit mountain grasslands and rocky areas of N. America, while some occur in Eurasia. Marmots hibernate for up to eight months, depending on the species.

BLACK-TAILED PRAIRIE DOG
Cynomys ludovicianus
Active during daytime, this ground squirrel lives in large groups in "towns" consisting of extensive communal burrows.

HARRIS'S ANTELOPE SQUIRREL
Ammospermophilus harrisii
An agile inhabitant of the Sonora Desert and northern Mexico, this rodent is active in the heat of the day, but hibernates during winter.

POCKET MICE AND KANGAROO RATS

Mostly common, with a few rare species, the Heteromyidae are found in varied habitats from Canada to Central America, with kangaroo rats living mainly in deserts. Pocket mice typically run on four feet, but kangaroo rats hop on two large hind feet.



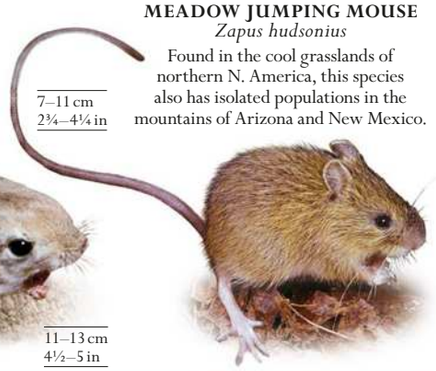
DESERT POCKET MOUSE
Chaetodipus penicillatus
This species is one of many small nocturnal rodents that inhabit the open sandy deserts of the S.W. USA and N. Mexico.

MERRIAM'S KANGAROO RAT
Dipodomys merriami
Bounding away with its tail outstretched, this nocturnal inhabitant of the N. American deserts looks like a miniature kangaroo.

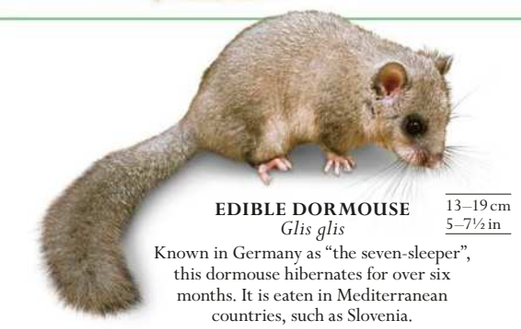
JUMPING MICE

The families Dipodidae (jerboas), Zapodidae (jumping mice), and Sminthidae (birch mice) are made up of rodents that have a long tail and powerful hind feet that enable them to bound about like miniature kangaroos.

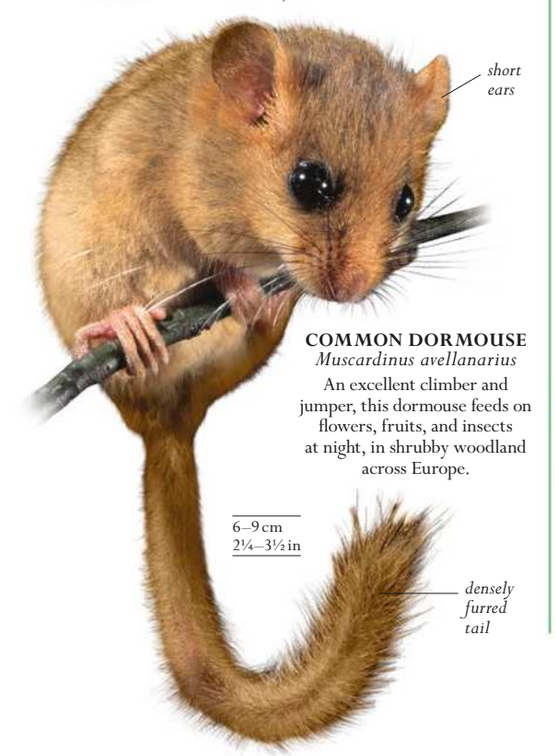
LESSER EGYPTIAN JERBOA
Jaculus jaculus
This desert species is found across N. Africa, from Senegal to Egypt, south to Somalia, and east to Iran.



MEADOW JUMPING MOUSE
Zapus hudsonius
Found in the cool grasslands of northern N. America, this species also has isolated populations in the mountains of Arizona and New Mexico.



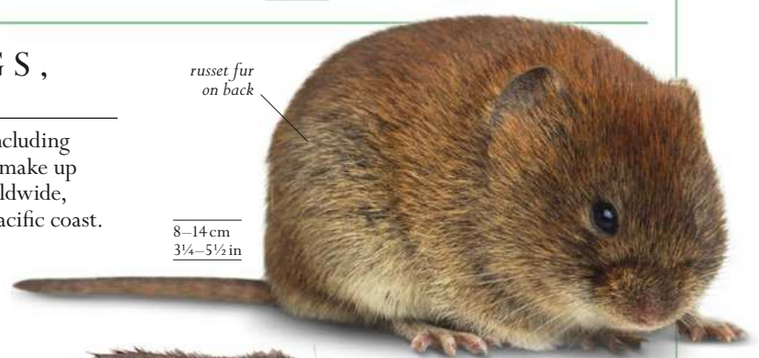
EDIBLE DORMOUSE
Glis glis
13–19 cm
5–7½ in
Known in Germany as "the seven-sleeper", this dormouse hibernates for over six months. It is eaten in Mediterranean countries, such as Slovenia.



COMMON DORMOUSE
Muscardinus avellanarius
An excellent climber and jumper, this dormouse feeds on flowers, fruits, and insects at night, in shrubby woodland across Europe.

VOLES, LEMMINGS, AND MUSKRATS

About 765 chubby, short-tailed rodents, including hamsters, voles, lemmings, and muskrats, make up the family Cricetidae. They are found worldwide, from western Europe to Siberia and the Pacific coast.



BANK VOLE
Myodes glareolus
Active mostly at dawn and night, this typical vole inhabits scrub, woodlands, and gardens across most of W. Europe and east into Russia.

COMMON VOLE
Microtus arvalis
A common burrowing inhabitant of grasslands across most of N. Europe, this vole also occurs further east and in Russia.

EURASIAN WATER VOLE
Arvicola amphibius
In Britain and parts of Europe, this vole occurs near waterside habitats, but in Russia and Iran, it lives away from water, digging extensive burrow systems.

NORWAY LEMMING
Lemmus lemmus
The main small mammal of the European tundra, the lemming's fluctuating population affects the breeding success of many Arctic predators.

STEPPE VOLE
Lagurus lagurus
The only species in its genus, this vole lives in the dry, grassy plains that stretch from Ukraine to W. Mongolia.

MUSKRAT
Ondatra zibethicus
Originally an inhabitant of rivers, ponds, and streams in N. America, the muskrat has been introduced to Europe and is now widespread.

»

» VOLES, LEMMINGS, AND MUSKRATS

STRIPED DWARF HAMSTER
Cricetulus barabensis
By raiding crops to gather seeds and grain, this rodent can become a serious pest in farming areas. Farmers destroy its burrows while ploughing.

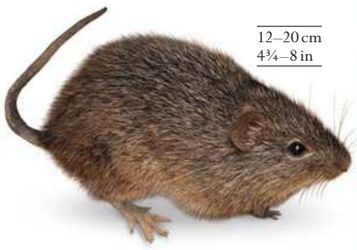
ROBOROVSKI'S DESERT HAMSTER
Phodopus roborovskii
From the dry grasslands of C. Asia, this tiny animal is popular as a pet. During the breeding season, it can produce three to four litters.

COMMON HAMSTER
Cricetus cricetus
This burrowing species lives alone and hibernates underground through the winter. Its burrows may contain up to 65 kg (145 lb) of stored food.

LONG-HAIRED GOLDEN HAMSTER
Mesocricetus auratus
The golden hamster has been selectively bred to create exotic forms, such as this albino variety, that would not survive in the wild.

GOLDEN HAMSTER
Mesocricetus auratus
Originally from Syria, where it is now an endangered species, this hamster has become a favourite household pet in Europe and N. America.

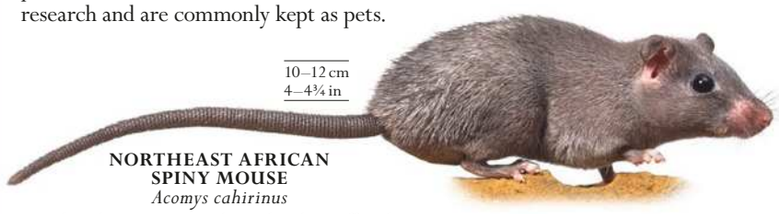
WHITE-FOOTED MOUSE
Peromyscus leucopus
A very common and adaptable creature, this deer mouse inhabits almost every type of land habitat in central and the E. USA.



HISPID COTTON RAT
Sigmodon hispidus
This short-lived, surface-dwelling herbivore occurs in grassland habitats in the S. USA and Mexico.

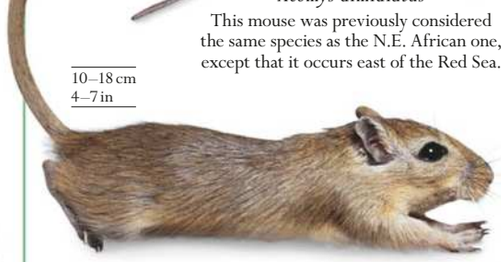
MICE, RATS, AND RELATIVES

One fifth of all mammal species belong to this huge family. The Muridae are distributed almost worldwide, including the polar regions. Some species carry serious diseases, and others are significant agricultural pests. However, several are used in medical research and are commonly kept as pets.

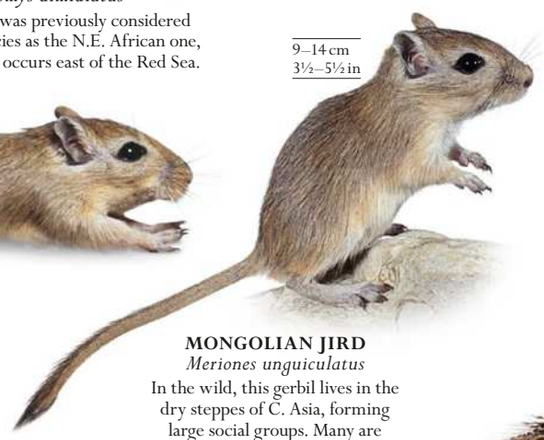


NORTHEAST AFRICAN SPINY MOUSE
Acomys cahirinus
Like other spiny mice, this rodent has stiffened hairs on its body for protection and very thin skin, which permits easy cooling in its hot, dry habitat.

ARABIAN SPINY MOUSE
Acomys dimidiatus
This mouse was previously considered the same species as the N.E. African one, except that it occurs east of the Red Sea.



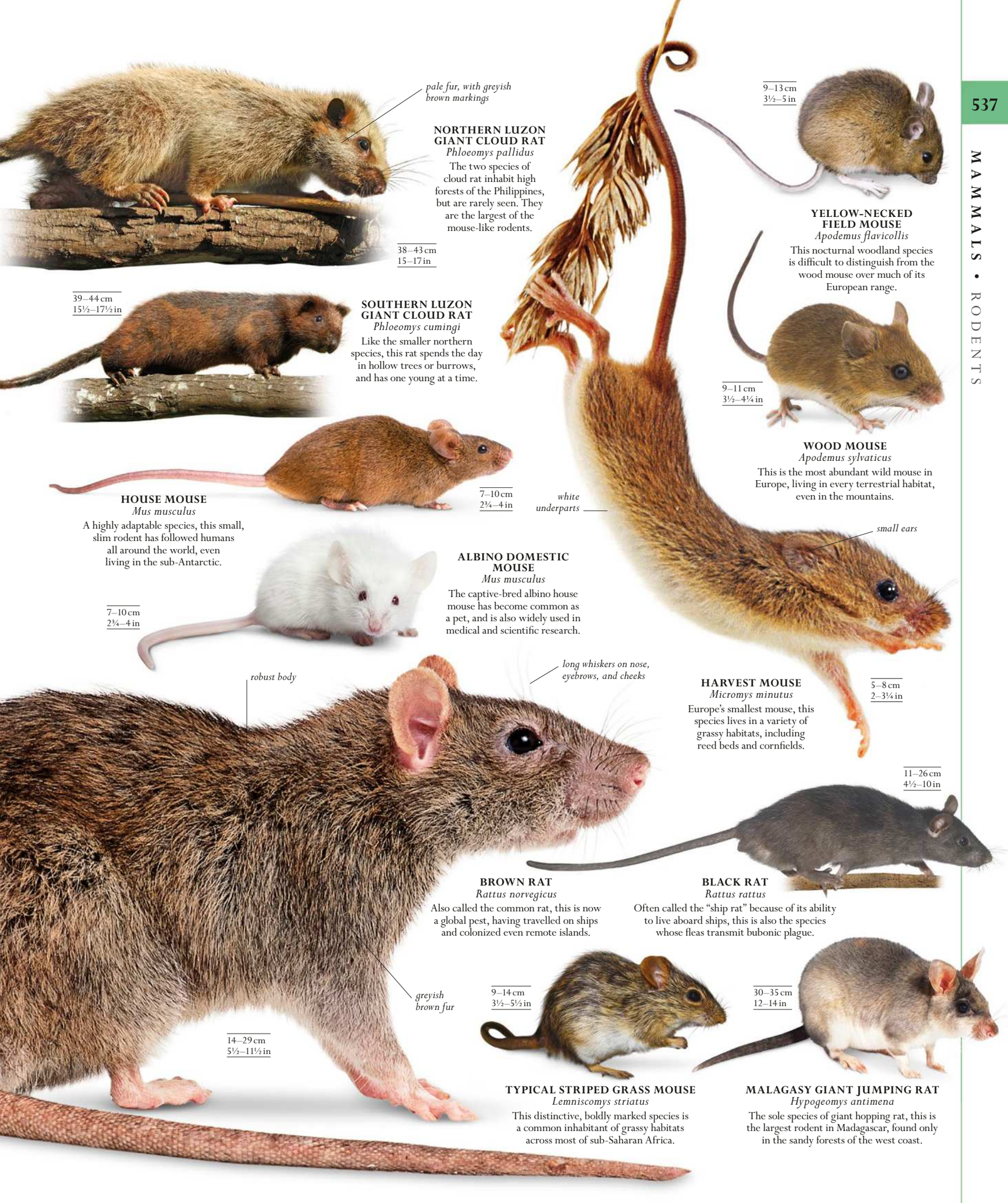
SHAW'S JIRD
Meriones shawii
Common in deserts of N. Africa and the Middle East, this rodent does not hibernate, but survives the winter by storing up to 10 kg (22 lb) of food in its burrows.



MONGOLIAN JIRD
Meriones unguiculatus
In the wild, this gerbil lives in the dry steppes of C. Asia, forming large social groups. Many are now kept as pets.

PALLID GERBIL
Gerbillus floweri
Like most small desert rodents, this gerbil has a pale body. It is widespread in N. Africa and the Middle East, where its coloration provides good camouflage.

FAT-TAILED JIRD
Pachyuromys duprasi
Like many small, desert-living mammals, this species stores fat in its tail. The tail has no fur, allowing it to radiate excess body heat.



NORTHERN LUZON GIANT CLOUD RAT
Phloeomys pallidus
The two species of cloud rat inhabit high forests of the Philippines, but are rarely seen. They are the largest of the mouse-like rodents.

SOUTHERN LUZON GIANT CLOUD RAT
Phloeomys cumingi
Like the smaller northern species, this rat spends the day in hollow trees or burrows, and has one young at a time.

YELLOW-NECKED FIELD MOUSE
Apodemus flavicollis
This nocturnal woodland species is difficult to distinguish from the wood mouse over much of its European range.

WOOD MOUSE
Apodemus sylvaticus
This is the most abundant wild mouse in Europe, living in every terrestrial habitat, even in the mountains.

HOUSE MOUSE
Mus musculus
A highly adaptable species, this small, slim rodent has followed humans all around the world, even living in the sub-Antarctic.

ALBINO DOMESTIC MOUSE
Mus musculus
The captive-bred albino house mouse has become common as a pet, and is also widely used in medical and scientific research.

HARVEST MOUSE
Micromys minutus
Europe's smallest mouse, this species lives in a variety of grassy habitats, including reed beds and cornfields.

BROWN RAT
Rattus norvegicus
Also called the common rat, this is now a global pest, having travelled on ships and colonized even remote islands.

BLACK RAT
Rattus rattus
Often called the "ship rat" because of its ability to live aboard ships, this is also the species whose fleas transmit bubonic plague.

TYPICAL STRIPED GRASS MOUSE
Lemniscomys striatus
This distinctive, boldly marked species is a common inhabitant of grassy habitats across most of sub-Saharan Africa.

MALAGASY GIANT JUMPING RAT
Hypogeomys antimena
The sole species of giant hopping rat, this is the largest rodent in Madagascar, found only in the sandy forests of the west coast.

BAMBOO RATS AND RELATIVES

The family Spalacidae includes blind mole rats, bamboo rats, root rats, and zokors. Big, protruding incisors characterize the blind mole rats. Adapted to an underground life, they have no external eyes and ears. The bamboo rats of eastern Asia have visible eyes.

17–35 cm
6½–14 in

GREATER MOLE RAT
Spalax microphthalmus
This blind species has sensory bristles running from its snout to its eye sockets. It is native to the steppes of Ukraine and S.E. Russia.

15–26 cm
6–10 in

LESSER BAMBOO RAT
Cannomys badius
Found from Nepal to Vietnam, this single species of its genus digs deep burrows in forests, grassy areas, and sometimes gardens.

SPRINGHARES

Resembling rabbits in size and behaviour, the Pedetidae differ in producing only one young at a time. They breed all year round, but living in dry, open habitats makes them vulnerable to predators.

33–46 cm
13–18 in

EAST AFRICAN SPRINGHARE
Pedetes surdaster
Springhares escape their noctural predators with kangaroo-like leaps. Less common than *Pedestes capensis*, this species lives on the Serengeti plain in Africa.

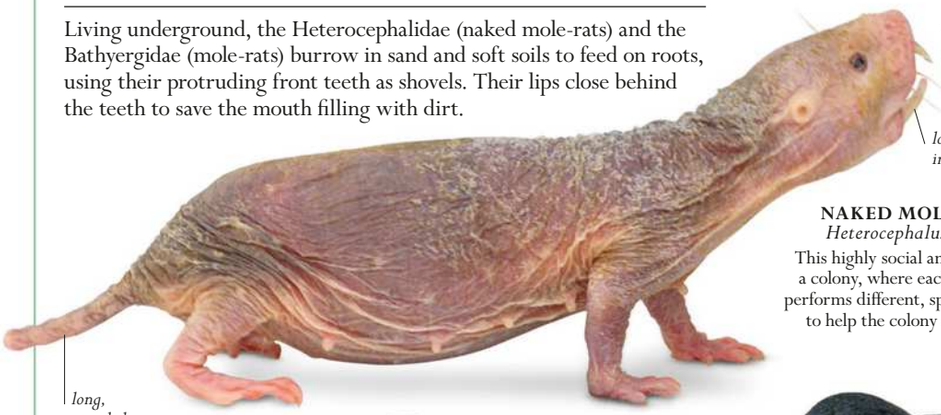
SOUTH AFRICAN SPRINGHARE
Pedetes capensis
This species leaves its burrow at night to nibble at the grass and herbs found in the dry regions of southern Africa.

33–46 cm
13–18 in

long tufted tail

AFRICAN MOLE-RATS

Living underground, the Heterocephalidae (naked mole-rats) and the Bathyergidae (mole-rats) burrow in sand and soft soils to feed on roots, using their protruding front teeth as shovels. Their lips close behind the teeth to save the mouth filling with dirt.



7–11 cm
2¾–4½ in

long, protruding incisor teeth

NAKED MOLE-RAT
Heterocephalus glaber
This highly social animal lives in a colony, where each individual performs different, specialized jobs to help the colony as a whole.

long, rounded tail

10–19 cm
4–7½ in

COMMON MOLE-RAT
Cryptomys hottentotus
Found from Tanzania to South Africa, this common species lives in soft soils and farmland, where it feeds mainly on roots.

NAMAQUA DUNE MOLE-RAT
Bathyergus janetta
Native to Namibia and southwestern South Africa, this species uses its forefeet rather than its teeth to dig burrows.

17–24 cm
6½–9½ in

NEW WORLD PORCUPINES

Tree-dwelling animals in American forests, the Erethizontidae have short spines, which are generally less than 10 cm (4 in) long. Most have a prehensile tail to grip branches.

0.6–1.3 m
2–4¼ ft

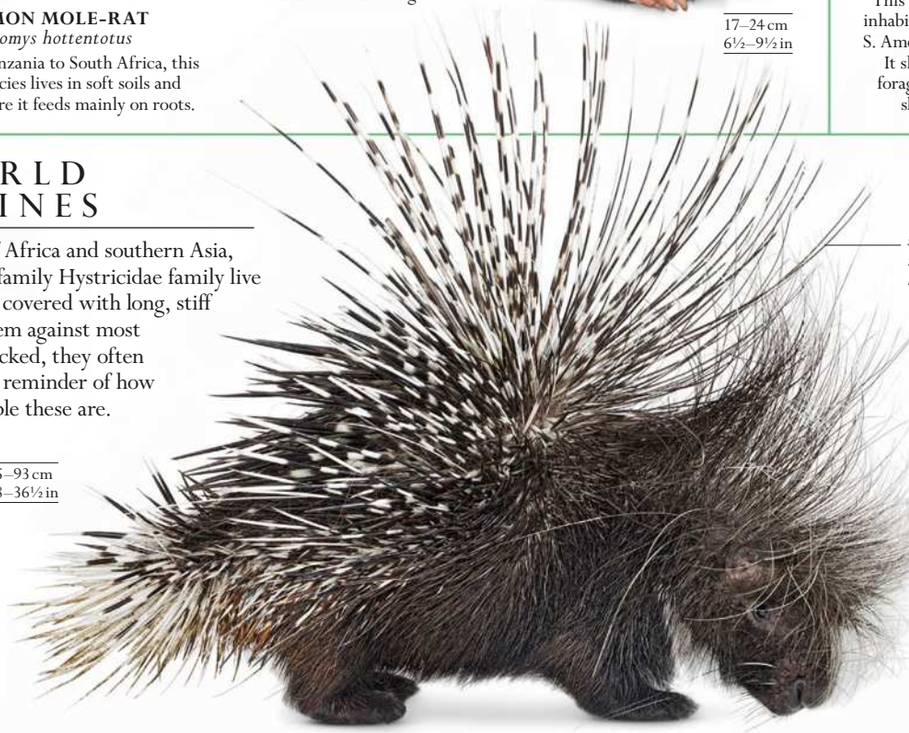
NORTH AMERICAN PORCUPINE
Erethizon dorsatus
This forest dweller is found throughout N. America, from Alaska to Mexico. Its spines are hidden among its shaggy fur.

44–56 cm
17½–22 in

BRAZILIAN PORCUPINE
Coendou prehensilis
This nocturnal species inhabits forested areas of S. America and Trinidad. It sleeps by day and forages for leaves and shoots at dusk.

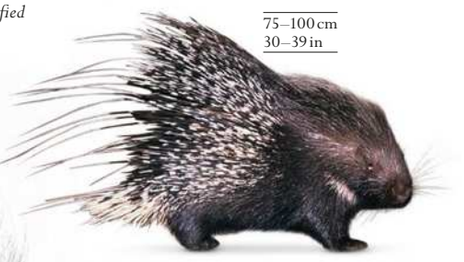
OLD WORLD PORCUPINES

Found across most of Africa and southern Asia, the 11 species of the family Hystricidae family live in burrows. They are covered with long, stiff quills that protect them against most predators. When attacked, they often rattle their quills as a reminder of how sharp and impenetrable these are.



spines are modified hair

CRESTED PORCUPINE
Hystrix cristata
45–93 cm
18–36½ in
Widespread across the northern half of Africa, except the Sahara, the crested porcupine is a familiar nocturnal rodent.



75–100 cm
30–39 in

CAPE PORCUPINE
Hystrix africaeaustralis
Found in savanna across most of southern Africa, this species forages at night, alone or in groups, sniffing out roots and berries.

VISCACHAS AND CHINCHILLAS

All six species of the family Chinchillidae from South America have a prominent tail and large hind feet. They normally live in social groups, inhabiting burrows or rocky outcrops. Most species are now quite rare because of their exploitation for fur and their status as pests.

large ears help regulate body temperature

long whiskers aid spatial awareness

CHINCHILLA
Chinchilla sp.
Widely prized for their fur, chinchillas have a fine, thick coat that insulates them against the cold in their Andean home.

22–38 cm
9–15 in

bushy tail balances the body

30–45 cm
12–18 in

MOUNTAIN VISCACHA
Lagidium viscacia
This agile rodent has dense fur to protect it from the cold at night. It lives on steep, rocky, mountain slopes.

DASSIE RAT

This single species in the family Petromuridae is found only in southern Africa. Its peculiar, flat skull and soft ribs are adaptations to living in crevices and under stones, and distinguish it from all other rodents.

13–25 cm
5–10 in

DASSIE RAT
Petromus typicus
Living on dry, rocky hillsides, this rodent emerges from crevices at dawn and dusk to forage for seeds and shoots.

CANE RAT

The two species of the family Thryonomyidae have pale brown, coarse, flattened hair that blends with their surroundings in dry grass and cane thickets. Cane rats produce two small families of well-developed young per year.

41–77 cm
16–30 in

CANE RAT
Thryonomys sp.
There are two species of African cane rats: one lives in savanna grasslands and the other in reedbeds and marshes.

PACARANA

The single species of the family Dinomyidae is a shy, bulky, slow-moving, and almost defenceless animal. It lives alone or in pairs in montane forests, where it is preyed upon by jaguars and humans.

PACARANA
Dinomys branickii
Threatened by loss of its S. American forest habitat, and hunted for food, the pacarana is now an endangered species.

70–80 cm
28–32 in

GUINEA PIGS, MARAS, AND CAPYBARA

Including some of South America's most widespread and abundant rodents, the Caviidae occur from mountain meadows to tropical flood plains, and breed all year round. All but the maras and capybara are short-legged and dumpy animals.

BRAZILIAN GUINEA PIG
Cavia aperea
Guinea pigs mostly live in lowland habitats, but this species is also found in the Andes, from Peru to Chile.

20–40 cm
8–16 in

ROSETTE GUINEA PIG
Cavia porcellus
Several coat variations occur in pet guinea pigs. In this one, the fur forms substantial spiky whorls over the body.

20–40 cm
8–16 in

LONG HAIR GUINEA PIG
Cavia porcellus
Often kept as a pet, in captivity this long-haired breed needs grooming to prevent its fur from becoming tangled.

20–40 cm
8–16 in

SHORT HAIR GUINEA PIG
Cavia porcellus
First domesticated more than 500 years ago for food, guinea pigs have since become popular pets worldwide.

long ears

60–80 cm
23½–32 in

PATAGONIAN MARA
Dolichotis patagonum
Extensive shared burrow systems and communal breeding habits are among the unusual features of these long-legged rodents.

CRESTED PORCUPINE
Hystrix cristata

With its long, barbed quills raised in threat, the crested porcupine is an intimidating prospect. A predator that has had the painful experience of being spiked is unlikely ever to attempt another attack. Lions, hyenas, and even people have been known to die from infected quill injuries. Despite this impressive means of defence, the porcupine is a peaceable and rather nervous animal, easily startled, and more likely to flee danger than stand its ground. Porcupines live alone or in family groups, sharing extensive burrow systems. Crested porcupines occur throughout much of northern Africa. The species was also once widespread in southern Europe – the population found in Italy may be a relic of former times or the result of a more recent introduction, perhaps by the Romans.

SIZE 45–93 cm (18–36½ in)
HABITAT Savanna grassland, light woodland, rocky terrain
DISTRIBUTION Northern Africa as far south as Tanzania, except Sahara Desert; also Italy
DIET Mainly roots, fruits, and tubers; occasionally carrion

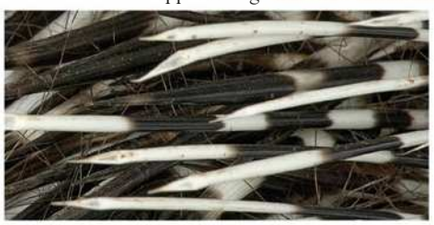
< SPIKY HAIR-DO
Raising the quills creates an illusion of size. A cornered porcupine will stand tall and try to bluff its way out of trouble. If this fails, it will turn tail and charge backwards, shoving its spiky rear end in the face of its attacker.

EAR >
The small ears are largely hidden in the coarse hair. The porcupine has good hearing, which it uses to avoid danger, shuffling off into the night if it hears another animal approaching.

v EYE
A porcupine's eyesight is poor, but then there is often little to see in the darkness of an African night. It uses its sharp senses of hearing and smell to find its way.

v MOUTH AND TEETH
Porcupines have the specialized gnawing teeth typical of rodents, enabling them to chew tough roots and tubers. The muscles that control the jaws are immensely powerful.

QUILLS-A-QUIVER >
Porcupine quills are greatly enlarged hairs. They can be raised by larger versions of the tiny muscles that create goosebumps in our own skin.



like its quills, the porcupine's thin coat of coarse hair can also be raised in alarm

RATTLING TAIL ^
The quills of the tail are swollen and hollow. The porcupine shakes them when alarmed and the soft rattling sound warns its enemies that this is a well-armed opponent.

< ^ FEET AND CLAWS
Porcupines walk on the flat soles of their feet, with a slightly clumsy, shambling gait. The soles are hairless and padded. They have short toes and strong claws, well suited to digging.

CAPYBARA

The largest rodent, the capybara, is one of four species in the Caviidae subfamily Hydrochoerinae. Capybaras generally breed once a year; the offspring are born at the end of the wet season, when the grass is most nutritious. They may live up to six years.

CAPYBARA
Hydrochoeris hydrochaeris
As big as a pig, this is the world's largest rodent. It lives a semi-aquatic life in the swamps of S. America.

1–1.3 m
3¼–4¼ ft

HUTIAS, SPINY RATS, AND COYPU

A Central and South American family, the Echimyidae comprises 99 species that live in a variety of habitats, and includes tree-dwelling and burrowing spiny rats, and the semi-aquatic coypu. Although they vary in size, fur type, and dentition as well as diet, phylogenetic and molecular analyses suggest they belong in the same group.

16–30 cm
6½–12 in

SPINY RAT
Proechimys sp.
These rodents have a spiny protective coat. This feature has evolved in parallel to the spiny mice of Africa.

30–43 cm
12–17 in

DESMAREST'S CUBAN HUTIA
Capromys pilorides
This hutia is common in Cuba. Other surviving hutia species face extinction because of a loss of their habitat and hunting.

47–58 cm
18½–23 in

COYPU
Myocastor coypus
This animal has distinctively shaggy fur and huge orange front teeth. It also has webbed hind feet for swimming and a thick, scaly tail.

PACAS

This family includes two species of nocturnal rodent from Central and South America. The Cuniculidae resemble small pigs as they root about on the forest floor for fruits, seeds, and roots.

50–75 cm
20–30 in

LOWLAND PACA
Cuniculus paca
Mainly a forest inhabitant, this rodent lives in the northern part of S. America, from Mexico to Paraguay.

DEGUS, ROCK RATS, AND RELATIVES

The molar teeth of these small, silky furred rats form a figure-of-eight shape when worn, giving them their Latin name. The Octodontidae are widespread in the southern part of South America.

16–22 cm
6½–9 in

DEGU
Octodon degus
This species is found on the western slopes of the Andes in Chile. Its tail breaks off easily if caught by a predator.

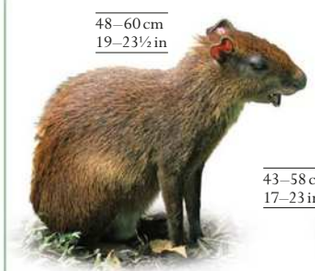
AGOUTIS

Active during the day, these long-legged, running rodents of the family Dasyproctidae are very shy. They breed all year round but have only two young at a time, which can run within an hour of birth.

RED-RUMPED AGOUTI
Dasyprocta leporina
Found in forested areas of northeastern S. America and the Lesser Antilles, this species can be identified by its light orange rump.

48–60 cm
19–23½ in

48–60 cm
19–23½ in



CENTRAL AMERICAN AGOUTI
Dasyprocta punctata
With a range that extends from Mexico south to Argentina, this agouti mainly feeds on fruits, but may also eat crabs. Pairs are thought to stay together for life.

43–58 cm
17–23 in

AZARA'S AGOUTI
Dasyprocta azarae
An inhabitant of the forests of S. Brazil, Paraguay, and N. Argentina, this agouti barks when alarmed. It eats a variety of seeds and fruits.

TREE SHREWS

These small mammals look and behave like squirrels. They are active in the daytime and spend much of their time foraging for food on the ground.

Tree shrews are native to the tropical rainforests of Southeast Asia. They are unrelated to the true shrews and have their own order, Scandentia. Sharp claws on all their fingers and toes enable tree shrews to climb trees rapidly but, despite their name, most of them are only partly arboreal. Their mixed diet includes insects, worms, fruits, and sometimes small mammals, reptiles, and birds.

Some tree shrews are solitary, while others live in pairs or groups. They are rapid breeders, raising their young in nests in tree crevices or on branches. The female pays her brood little attention, making only the occasional short visit to suckle them.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	SCANDENTIA
FAMILIES	2
SPECIES	23

PEN-TAILED TREE SHREW

The family Ptilocercidae has only one member, the Southeast Asian pen-tailed tree shrew. The species is named for its long, feathery tail, which resembles a quill pen. This aids balance when climbing.

13–15 cm
5–6 in

PEN-TAILED TREE SHREW
Ptilocercus lowii
This species has a rather spindly tail with a brushy tip, unlike most other tree shrews, which have a thick, bushy tail.

TREE SHREWS

Members of the family Tupaiidae have a long snout, which is used to locate insects and other invertebrates as well as fruits and leaves. Tree shrews also have sharp claws on all their fingers and toes, helping them to climb trees rapidly.

LARGE TREE SHREW
Tupaia tana
Tree shrews are diurnal inhabitants of S.E. Asian forests. This species is found in Borneo and Sumatra and on nearby islands.

COLUGOS

The two species that form the order Dermoptera are gliding, rather than flying, mammals. They are found in the rainforests of Southeast Asia.

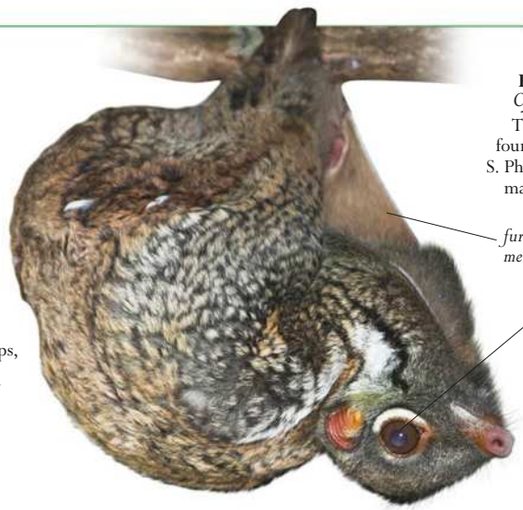
The colugos are distinguished by a furry membrane that stretches from the neck to the tips of the fingers and tail. When the limbs are splayed this membrane spreads out, allowing the lemur to manoeuvre in the air as it glides from tree to tree. The distance covered in a glide may be more than 100 m (330 ft). Colugos live in the canopy, hanging upside down from branches or sheltering in cracks or hollow trees by day and emerging at night to feed on fruits and leaves. They are almost unable to move on the ground.

The teeth of colugos are unlike those of any other mammal. In the lower jaw, the teeth are arranged like combs and are believed to be used for grooming as well as for feeding.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	DERMOPTERA
FAMILIES	1
SPECIES	2

FLYING LEMURS

The two members of the Cynocephalidae have forward-facing eyes that provide depth perception This helps them judge distances when gliding from tree to tree. They also have unusual comb-like lower teeth, used to strain food such as fruits and flowers.



SUNDA COLUGO
Cynocephalus variegatus
This lemur lives alone or in small groups, inhabiting tree-holes or resting high on treetops in the tropical forests of S.E. Asia and the Indonesian islands.

PHILIPPINE FLYING LEMUR
Cynocephalus volans
The only local species found in the forests of the S. Philippines, where it feeds mainly on young leaves.

PRIMATES

The order to which humans belong, primates have a large brain relative to their size and forward-facing eyes which give them 3-D vision.

With the exception of a few species, including humans, primates are restricted to tropical and subtropical regions of the Americas, Africa, and Asia. They range in size from a mouse lemur, weighing 30 g (1 oz), to a gorilla weighing up to 200 kg (440 lb).

Primates rely more on vision than on smell. Many are arboreal and have characteristics such as stereoscopic vision, allowing good judgement of distance for jumping between trees; opposable thumbs and a prehensile tail for grasping branches; long legs for leaping; and long arms for swinging. Some primates have specialized diets, but many other species are omnivorous.

MAJOR GROUPS

Primates are divided into two suborders. The Strepsirrhini includes the mostly nocturnal lemurs, lorises, galagos, and their relatives. These species have a better developed sense of smell than other primates. The Haplorrhini includes the New and Old World monkeys and the apes, many of which are diurnal, and so more reliant on vision than the Strepsirrhini.

SOCIAL PATTERNS

Most primates are highly social, living in small family groups, single-male harems, or large mixed-sex troops. Many species are characterized by high levels of male competition for females. Sexual selection favouring the largest or most dominant males has led to sexual dimorphism – differences between males and females in body size or features such as canine teeth. The different sexes may also be differently coloured, a form of dimorphism known as sexual dichromatism.

Most New World monkeys are monogamous, with both parents sharing responsibility for raising their young. Old World monkeys tend to live in groups dominated by related females, and the males take little or no part in parental duties. Primates are generally slow to mature fully and slow to reproduce, but they are relatively long-lived. The larger apes have a potential lifespan of up to 45 years in the wild, and longer in captivity.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PRIMATES
FAMILIES	16
SPECIES	506

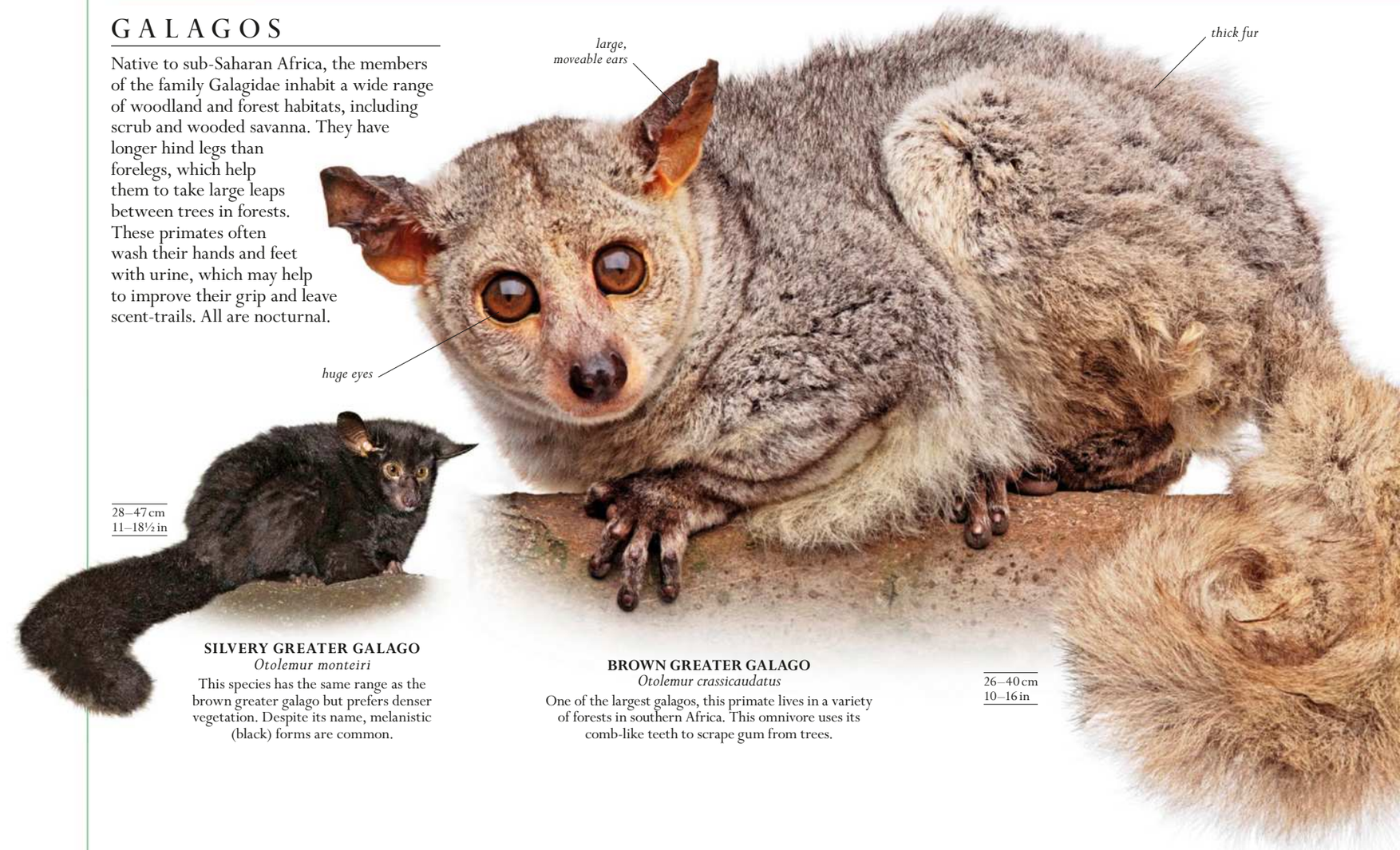
DEBATE

PRIMATE HOTSPOTS

Today scientists list more species of primates than a decade ago – most the result of subspecies (geographical variants) being recognized as new species. In the Amazon basin populations of monkeys separated by rivers and mountain ranges can differ in subtle ways – such as in the structure of their chromosomes. Some scientists believe that these monkeys diverged when their forest habitats became isolated due to geological activity many thousands of years ago. Such forests may contain many species isolated in this way and are a particular focus of conservation groups aiming to protect biodiversity.

GALAGOS

Native to sub-Saharan Africa, the members of the family Galagidae inhabit a wide range of woodland and forest habitats, including scrub and wooded savanna. They have longer hind legs than forelegs, which help them to take large leaps between trees in forests. These primates often wash their hands and feet with urine, which may help to improve their grip and leave scent-trails. All are nocturnal.



SILVERY GREATER GALAGO
Otolemur monteiri
This species has the same range as the brown greater galago but prefers denser vegetation. Despite its name, melanistic (black) forms are common.

BROWN GREATER GALAGO
Otolemur crassicaudatus
One of the largest galagos, this primate lives in a variety of forests in southern Africa. This omnivore uses its comb-like teeth to scrape gum from trees.

LORISES, POTTOS, AND ANGWANTIBOS

These small, nocturnal omnivores have a short tail, and their forelimbs and hind limbs are of equal length. The Lorisidae have opposable thumbs for grasping branches and they move much more slowly and sedately through the trees than the galagos – climbing rather than leaping.

30–34 cm
12–13½ in

SUNDA SLOW LORIS
Nycticebus coucang
As its name suggests, this loris moves slowly and deliberately through the trees. It inhabits tropical forest in S.E. Asia.

20–23 cm
8–9 in

PYGMY SLOW LORIS
Nycticebus pygmaeus
This species inhabits thick tropical rainforest and bamboo forest in Laos, Cambodia, Vietnam, and S. China.

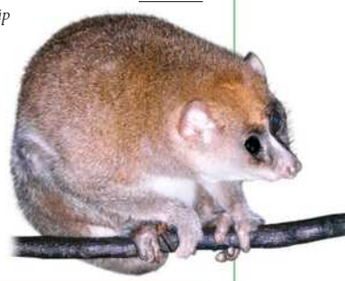
RED SLENDER LORIS
Loris tardigradus
Native to Sri Lanka, this slender primate moves carefully through the forest canopy on its long limbs.

18–21 cm
7–8½ in

30–40 cm
12–16 in

WEST AFRICAN POTTO
Perodicticus potto
A shy species, this primate lives in thick rainforest across equatorial Africa. A bony shield at the nape of its neck protects it against predators.

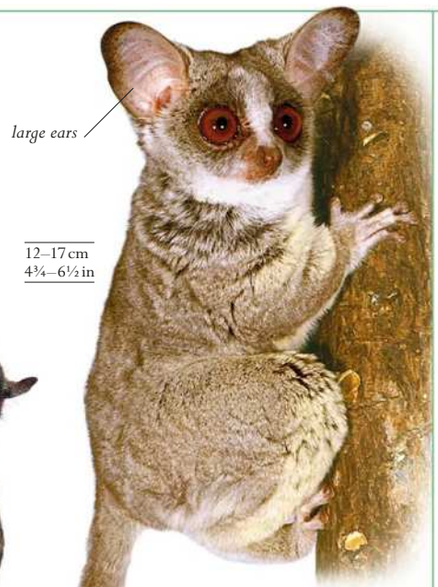
22–26 cm
9–10 in



GOLDEN ANGWANTIBO
Arctocebus aureus
Also called the golden potto, this species inhabits the understorey of moist lowland forest in equatorial W. and C. Africa.

SENEGAL BUSHBABY
Galago senegalensis
Widespread across C. Africa and parts of E. Africa, the lesser, or Senegal, bushbaby inhabits arid savanna woodland.

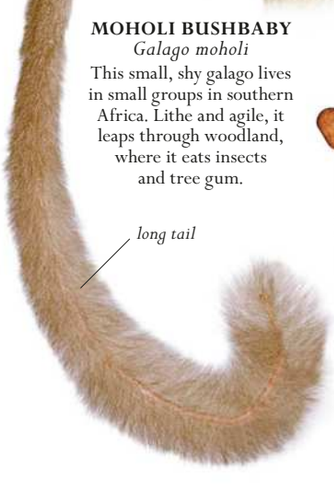
12–20 cm
4¾–8 in



12–17 cm
4¾–6½ in

DEMIDOFF'S BUSHBABY
Galagoides demidovii
Also called the dwarf bushbaby, this small primate uses its long hind legs to jump through rainforest canopies of W. and C. Africa.

12–17 cm
4¾–6½ in



MOHOLI BUSHBABY
Galago moholi
This small, shy galago lives in small groups in southern Africa. Lithe and agile, it leaps through woodland, where it eats insects and tree gum.

TARSIERS

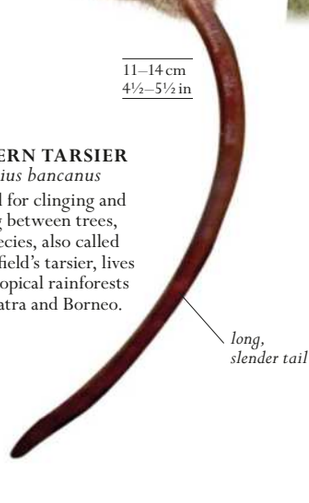
The small Tarsiidae are named for their greatly elongated anklebone or tarsus. These arboreal species have long limb bones, elongated fingers, and a long, thin tail. Their round head has very large eyes, which help them to see at night while hunting for insects.

PHILIPPINE TARSIER
Tarsius syrichta
Endemic to a variety of rainforest and scrub in the Philippines, this tarsier possesses the largest eyes relative to its body size among all mammals.

11–14 cm
4½–5½ in

11–14 cm
4½–5½ in

WESTERN TARSIER
Tarsius bancanus
Adapted for clinging and leaping between trees, this species, also called the Horsfield's tarsier, lives in the tropical rainforests of Sumatra and Borneo.



LEMURS

Found in forests across Madagascar, the family Lemuridae is made up of the most typical lemurs: mainly arboreal and quadrupedal. Most are cathemeral, meaning they are active during the day and night. In several species, males and females are differently coloured.

40–42 cm
16–16½ in

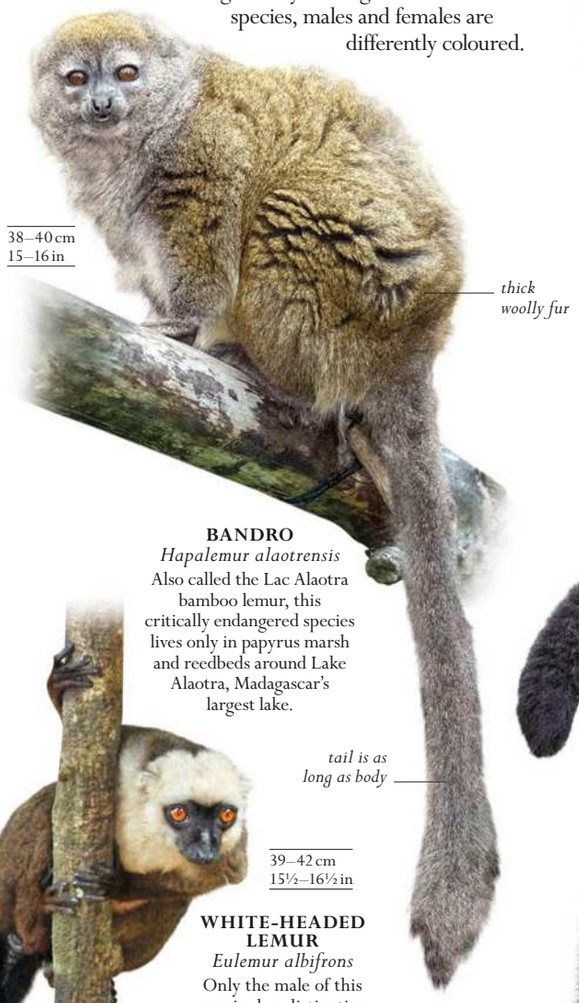
GREATER BAMBOO LEMUR
Prolemur simus
One of the rarest lemurs, this species lives in S.E. Madagascar, where it feeds almost exclusively on giant bamboo.

39–46 cm
15½–18 in

RING-TAILED LEMUR
Lemur catta
Living in groups of up to 25 individuals, this lemur often spends time on the ground. Its diet consists of fruits, vegetation, sap, and bark.

40–50 cm
16–20 in

BLACK-AND-WHITE RUFFED LEMUR
Varecia variegata
The largest lemur, this species eats a high proportion of fruits. Unusually for lemurs, it makes a leafy nest for its young.



38–40 cm
15–16 in

thick woolly fur

BANDRO
Hapalemur alaotrensis
Also called the Lac Alaotra bamboo lemur, this critically endangered species lives only in papyrus marsh and reedbeds around Lake Alaotra, Madagascar's largest lake.

35–42 cm
14–16½ in

RED-BELLIED LEMUR
Eulemur rubriventer
A monogamous species, this lemur lives in small groups that consist of a mated pair and their dependent young.

38–42 cm
15–16½ in

RED COLLARED LEMUR
Eulemur collaris
This lemur has a scent gland on its wrist, with which it perfumes its long, furry tail for use in communication.

tail is as long as body

39–42 cm
15½–16½ in

WHITE-HEADED LEMUR
Eulemur albifrons
Only the male of this species has distinctive white fur around its black face; the female has a grey face.

32–37 cm
12½–14½ in

red cheek patch in male

♂

MONGOOSE LEMUR
Eulemur mongoz
Primarily nocturnal during the dry season, the mongoose lemur becomes more diurnal at the start of the wet season.

BLACK LEMUR
Eulemur macaco
In this sexually dichromatic species, the colours of males and females vary. Only the male is black; the female is grey-brown with white ear tufts.

grasping hands

38–45 cm
15–18 in

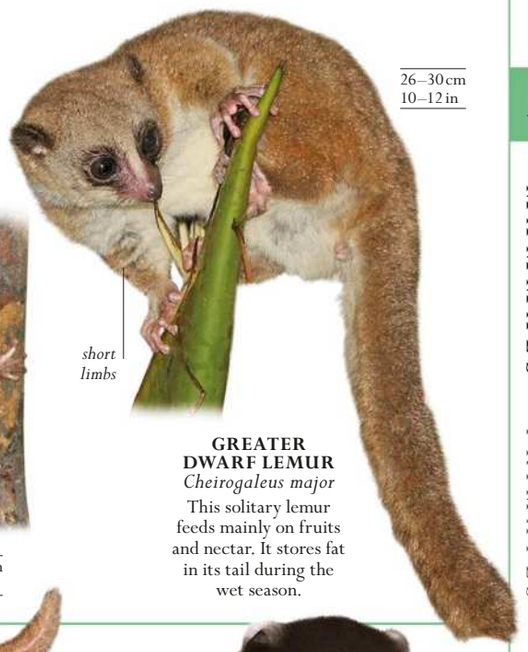
♀

MOUSE, DWARF, AND FORK-MARKED LEMURS

Among the smallest of all primates, the members of the family Cheirogaleidae have short limbs and large eyes. All are nocturnal, arboreal inhabitants of forests in Madagascar, and become torpid to survive the dry season.

22–30 cm
9–12 in

PALE FORK-MARKED LEMUR
Phaner pallescens
Adapted to eat tree gum, this lemur has a long tongue and large premolars for chiselling bark.



26–30 cm
10–12 in

short limbs

12–15 cm
4¾–6 in

GREY MOUSE LEMUR
Microcebus murinus
An omnivore, this lemur's diet includes insects, flowers, and fruits. The young are carried in their mother's mouth if moved (rather than clinging on to her fur).

10–15 cm
4–6 in

EASTERN RUFOUS MOUSE LEMUR
Microcebus rufus
Inhabiting a range of forest habitats, this omnivorous species consumes a variety of fruits, insects, and gum.

GREATER DWARF LEMUR
Cheirogaleus major
This solitary lemur feeds mainly on fruits and nectar. It stores fat in its tail during the wet season.

SPORTIVE LEMURS

The family Lepilemuridae consists of the sportive lemurs of Madagascar. These medium-sized lemurs have a prominent muzzle and large eyes, and are strictly arboreal and nocturnal. Their low-energy, leafy diet means that they are among the least active of all primates.

19–26 cm
7½–10 in

WHITE-FOOTED SPORTIVE LEMUR
Lepilemur leucopus
Greyish above and white below, this lemur spends lengths of time perched vertically on tree trunks, in between bouts of foraging for food.

23–26 cm
9–10 in

BLACK-STRIPED SPORTIVE LEMUR
Lepilemur dorsalis
This species lives in moist forest in N.W. Madagascar and nearby islands. It has a blunt muzzle and small ears.

AYE-AYE

There is only one species in the Daubentoniidae – the aye-aye of Madagascar. This nocturnal primate has large, bare ears; a shaggy coat; very long fingers; and continually growing incisor teeth.

30–37 cm
12–14½ in

AYE-AYE
Daubentonia madagascariensis
The aye-aye uses its elongated middle finger for locating and extracting insect larvae from dead wood.

SIFAKAS AND RELATIVES

The largest lemurs – the indri and sifakas – and the smaller avahis or woolly lemurs form the Indriidae of Madagascar. All members have long, powerful limbs for leaping between trees, and, with the exception of the indri, a long tail.

face mostly bare, with white fur along muzzle

42–50 cm
16½–20 in

long hind limbs

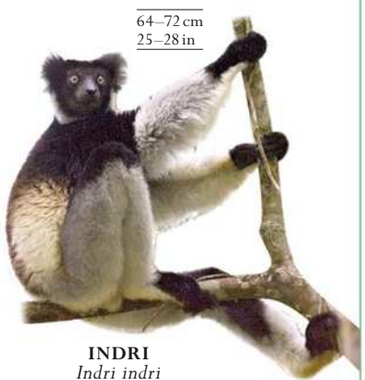
42–52 cm
16½–20½ in

MILNE-EDWARD'S SIFAKA
Propithecus edwardsi
Occurring in small family groups in southeastern Madagascar, this sifaka has a large opposable thumb for clinging to tree trunks.

COQUEREL'S SIFAKA
Propithecus coquereli
Like other sifakas, this primate crosses open ground by skipping on its hind legs, using its forearms for balance.

40–50 cm
16–20 in

VERREAUX'S SIFAKA
Propithecus verreauxi
Found in S.W. Madagascar, this sifaka is capable of leaping through cactus-like vegetation on its long legs without being injured.



64–72 cm
25–28 in

INDRI
Indri indri
The largest member of the lemur group, this is the only species to have a short, vestigial tail.

HOWLER, SPIDER, AND WOOLLY MONKEYS

The howler, spider, and woolly monkeys, and muriquis of the Atelidae are the largest New World monkeys. All have a prehensile tail that is used as a fifth limb when moving through the trees. Spider monkeys have longer limbs than the other members of the family.

GUATEMALAN BLACK HOWLER
Alouatta pigra
Found in the Yucatán Peninsula of Mexico, Belize, and Guatemala, this species forms groups of up to 11 individuals.

VENEZUELAN RED HOWLER
Alouatta seniculus
This howler monkey has an enlarged hyoid bone in the neck that allows it to make calls that can be heard several kilometres away.

MANTLED HOWLER
Alouatta palliata
Named after the "mantle" of long guard hair on its flanks, this howler monkey lives in C. America and northern S. America.

COLOMBIAN BLACK SPIDER MONKEY
Ateles fusciceps rufiventris
Like other spider monkeys, this subspecies does not have thumbs on its hands. It is found in Colombia and Panama.

GEOFFROY'S SPIDER MONKEY
Ateles geoffroyi
Active during the day, this fruit-eating species lives in relatively large groups of up to 35 individuals in forests throughout C. America.

SOUTHERN MURIQUI
Brachyteles arachnoides
Also known as the woolly spider monkey, this species, found in Brazilian forests, is critically endangered due to the loss of its habitat.

GREY WOOLLY MONKEY
Lagothrix cana
A powerfully built species, this monkey lives in large troops in the primary forests of Brazil, Bolivia, and Peru.

HUMBOLDT'S WOOLLY MONKEY
Lagothrix lagotricha
One of the largest New World monkeys, this species lives in lowland primary forest in the upper Amazon basin.

NIGHT MONKEYS

Also called owl monkeys, the members of the Aotidae are the only nocturnal monkeys in the New World. They are small, with large eyes set in a flat, round face with dense woolly fur. They have a well-developed sense of smell.

35–42 cm
14–16½ in

BLACK-HEADED NIGHT MONKEY
Aotus nigriceps
This monogamous species inhabits the central and upper Amazon basin in primary and secondary forests of Brazil, Bolivia, and Peru.

30–38 cm
12–15 in

NORTHERN NIGHT MONKEY
Aotus trivirgatus
Also called the three-striped monkey, this species is most active on moonlit nights. It lives in forests in Venezuela and northern Brazil.

TITI, SAKI, AND UAKARI MONKEYS

This family contains a range of small- to medium-sized monkeys. The Pitheciidae are diurnal, arboreal, and social. All share a common dental make-up, including large, splayed canine teeth that help them to deal with tough seeds and fruits.

black hair tipped with white

32–42 cm
12½–16½ in

RIO TAPAJÓS SAKI
Pithecia irrorata
Also called the bald-faced saki, this species lives in W. Brazil, N. Bolivia, and E. Peru. It eats predominantly seeds.

WHITE-FACED SAKI
Pithecia pithecia
Male white-faced or Guianan sakis are black with pale fur around the face, whereas females are grey-brown.

36–53 cm
14–21 in

37–48 cm
14½–19 in

MONK SAKI
Pithecia monachus
A shy primate, this species lives in the high canopy of forests in N.W. Brazil, Peru, Colombia, and Ecuador.

34–42 cm
13½–16½ in

BLACK-BEARDED SAKI
Chiropotes satanas
This species is known from S. Amazonia. The males possess a beard and large swellings on their forehead.

31–42 cm
12–16½ in

BLACK-FRONTED TITI
Callicebus nigrifrons
A fruit-eater, this titi is an inhabitant of Atlantic coastal forest around São Paulo in S.E. Brazil.

28–36 cm
11–14 in

COLLARED TITI MONKEY
Callicebus torquatus
Also known as the yellow-handed titi, this species prefers unflooded forests on sandy soils in Brazil. It feeds mostly on fruits and seeds.

hairless, red face

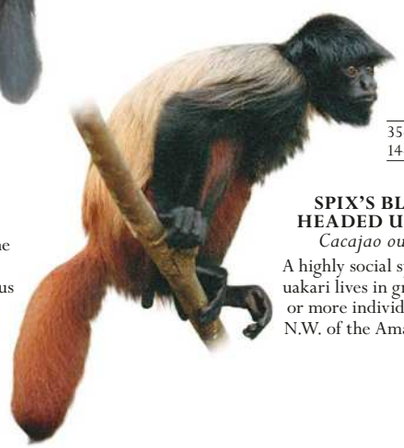
long, shaggy coat

36–57 cm
14–22½ in

RED BALD-HEADED UAKARI
Cacajao calvus rubicundus
Several subspecies of the bald-headed uakari inhabit seasonally flooded forests of the Amazon basin. The redness of the face is thought to signal the health of the monkey.

27–34 cm
10½–13½ in

COPPERY TITI
Plecturocebus cupreus
Found in rainforests of the S.W. Amazon Basin, the coppery titi is monogamous and territorial. It feeds mainly on fruits.

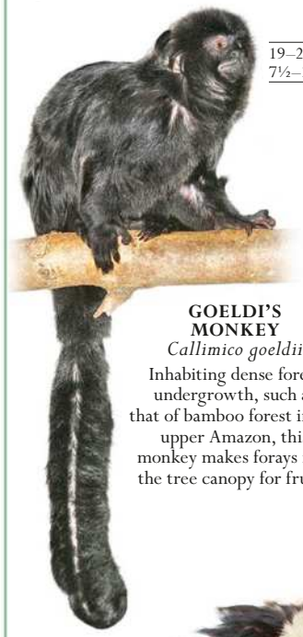


35–56 cm
14–22 in

SPIX'S BLACK-HEADED UAKARI
Cacajao ouakary
A highly social species, this uakari lives in groups of 30 or more individuals in the N.W. of the Amazon basin.

MARMOSETS AND TAMARINS

The Callitrichidae consists of relatively small social monkeys, which inhabit a variety of forests throughout tropical and subtropical Central and South America. They are all diurnal and arboreal and have forward-facing eyes and a short muzzle. Marmosets and tamarins have a long, non-prehensile tail, lack the third molar, and have claws instead of nails.



19–25 cm
7½–10 in

GOELDI'S MONKEY
Callimico goeldii
Inhabiting dense forest undergrowth, such as that of bamboo forest in the upper Amazon, this monkey makes forays into the tree canopy for fruits.

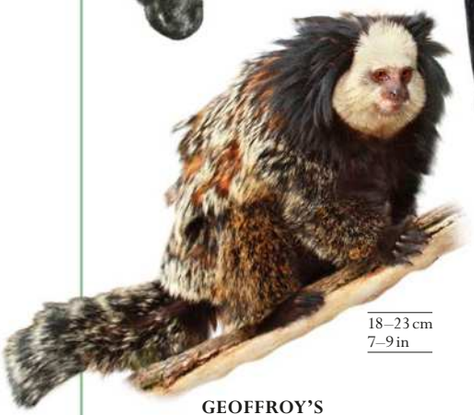
20–23 cm
8–9 in

SILVERY MARMOSET
Mico argentatus
A specialized gum-eater (gumivore), this marmoset has huge ears, narrow jaws, and short canine teeth for cutting into tree bark.

16–21 cm
6½–8½ in

COMMON MARMOSET
Callithrix jacchus
The female of this species generally mates with two males, both of whom assist with parental care of the usually twin offspring.

long, curved claws



18–23 cm
7–9 in

GEOFFROY'S TUFTED-EAR MARMOSET
Callithrix geoffroyi
Also called the white-headed marmoset, this species uses scent-marks to deter others from using the holes it makes in tree bark to extract gum.

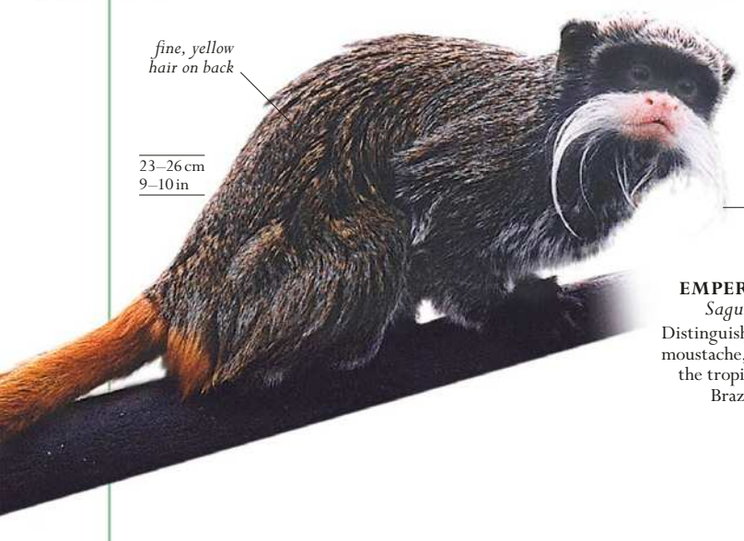
20–23 cm
8–9 in

BLACK-TUFTED-EAR MARMOSET
Callithrix penicillata
A monogamous species, this primate is diurnal and lives high in the rainforest canopy, where it feeds on tree sap.

12–15 cm
4¾–6 in

PYGMY MARMOSET
Cebuella pygmaea
The smallest monkey in the world, this species eats tree gum in seasonally flooded forests of the upper Amazon basin.

fine, yellow hair on back



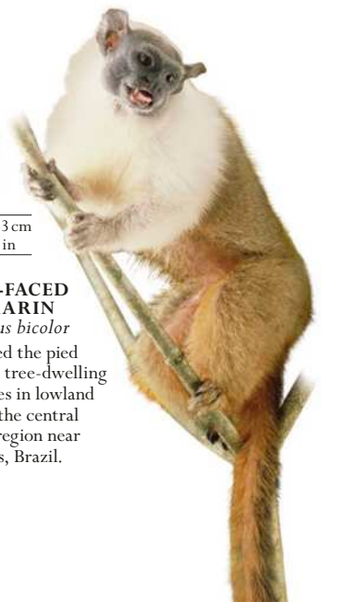
23–26 cm
9–10 in

white moustache

EMPEROR TAMARIN
Saguinus imperator
Distinguished by its long, white moustache, this tamarin lives in the tropical forests in Peru, Brazil, and Bolivia.

21–28 cm
8½–11 in

WHITE-LIPPED TAMARIN
Saguinus labiatus
The dominant female of this species releases chemical signals, called pheromones, that suppress reproduction in other female members of the group.

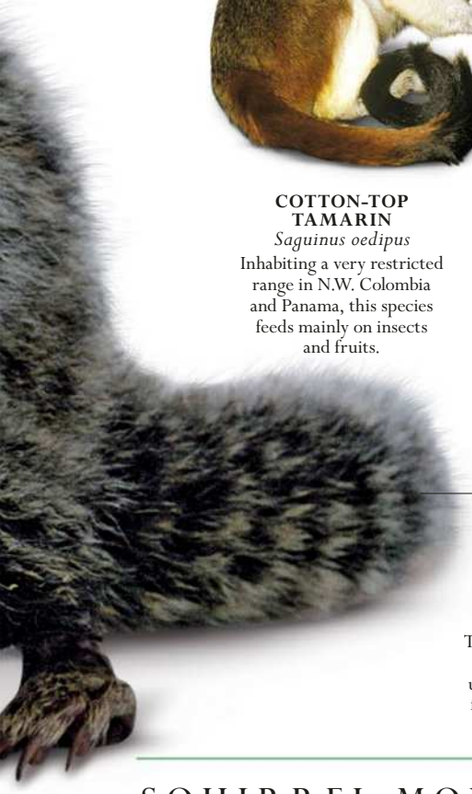


23–33 cm
9–13 in

BARE-FACED TAMARIN
Saguinus bicolor
Also called the pied tamarin, this tree-dwelling primate lives in lowland forest in the central Amazon region near Manaus, Brazil.

20–25 cm
8–10 in

COTTON-TOP TAMARIN
Saguinus oedipus
Inhabiting a very restricted range in N.W. Colombia and Panama, this species feeds mainly on insects and fruits.



banded tail

20–27 cm
8–10½ in

SADDLE-BACK TAMARIN
Saguinus fuscicollis
This tamarin lives in secondary forest and forest edges in the upper Amazon basin, foraging for insects, fruits, nectar, and tree sap and gum.

21–28 cm
8½–11 in

GOLDEN-HANDED TAMARIN
Saguinus midas
Found in northeast S. America, this tamarin has brightly coloured hands and feet, with claws on all digits except the big toe, which has a nail.

26–33 cm
10–13 in

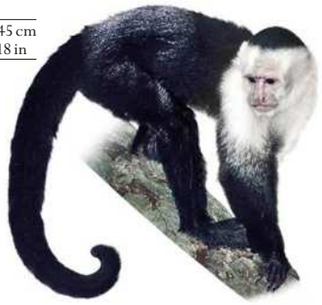
GOLDEN LION TAMARIN
Leontopithecus rosalia
Among the most endangered monkeys in the world, this species is found only in the Atlantic coastal forest of S.E. Brazil.

22–26 cm
9–10 in

GOLDEN-HEADED LION TAMARIN
Leontopithecus chrysomelas
Restricted to the Atlantic forest of southern Bahia in N.E. Brazil, this primate raises its mane to look bigger when in danger.

SQUIRREL MONKEYS AND CAPUCHINS

The family Cebidae once contained several monkey groups, but now only the squirrel monkeys and capuchins remain. They have large ears, a long tail, and forelimbs that are shorter than the hind limbs. Squirrel monkeys, of which there are eight Central and South American species, belong to the genus *Saimiri*. The capuchins comprise two genera, the tufted *Sapajus* and the untufted *Cebus*.



33–45 cm
13–18 in

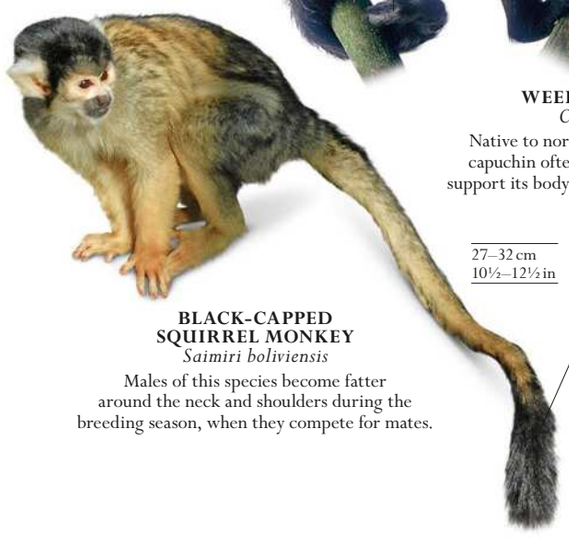
WHITE-HEADED CAPUCHIN
Cebus capucinus
The only capuchin found in C. America, the range of this primate extends from Honduras to the coasts of Colombia and Ecuador.

naked face

prehensile tail

37–46 cm
14½–18 in

WEEPER CAPUCHIN
Cebus olivaceus
Native to north-central S. America, this capuchin often uses its prehensile tail to support its body while feeding with its hands.



27–32 cm
10½–12½ in

long tail with a black tip

BLACK-CAPPED SQUIRREL MONKEY
Saimiri boliviensis
Males of this species become fatter around the neck and shoulders during the breeding season, when they compete for mates.

25–37 cm
10–14½ in

bright yellow limbs

nails on digits

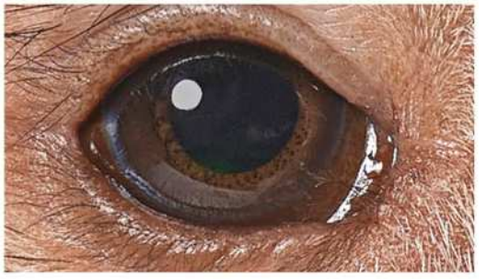
GUIANAN SQUIRREL MONKEY
Saimiri sciureus
A gregarious species, this monkey lives in large groups in a wide variety of forests in northern S. America to north-eastern S. America.

GUIANAN SQUIRREL MONKEY

Saimiri sciureus

Inquisitive and intelligent, the Guianan squirrel monkey has the largest brain mass to body mass of any primate. It is also very social, living in large mixed-sex groups of around 15–50 individuals. Guianan squirrel monkeys are synchronous breeders, with all young being born over a single week during the wet season (January–February) after a gestation period of about six months. The young initially cling to their mother's abdomen but then start riding on her back at about two weeks old. Their development is rapid, and the youngsters are weaned at six months and are fully independent four months later. Squirrel monkeys can live for up to 20 years.

SIZE 25–37 cm (10–14½ in)
HABITAT Lowland rainforest, mangroves
DISTRIBUTION French Guiana, Guyana, Suriname, and Brazil north of the Amazon
DIET Mainly insects, spiders, fruits, and flowers



EYE >
Sharp vision and good depth perception are a result of having large, close-set, forward-facing eyes. These features are of vital importance to a monkey that spends most of its time in the trees.

< NOSTRILS
Broad, laterally facing nostrils and a short nasal region belie an excellent sense of smell. Scent is important for social communication between members of the group and for finding mates and lost infants.

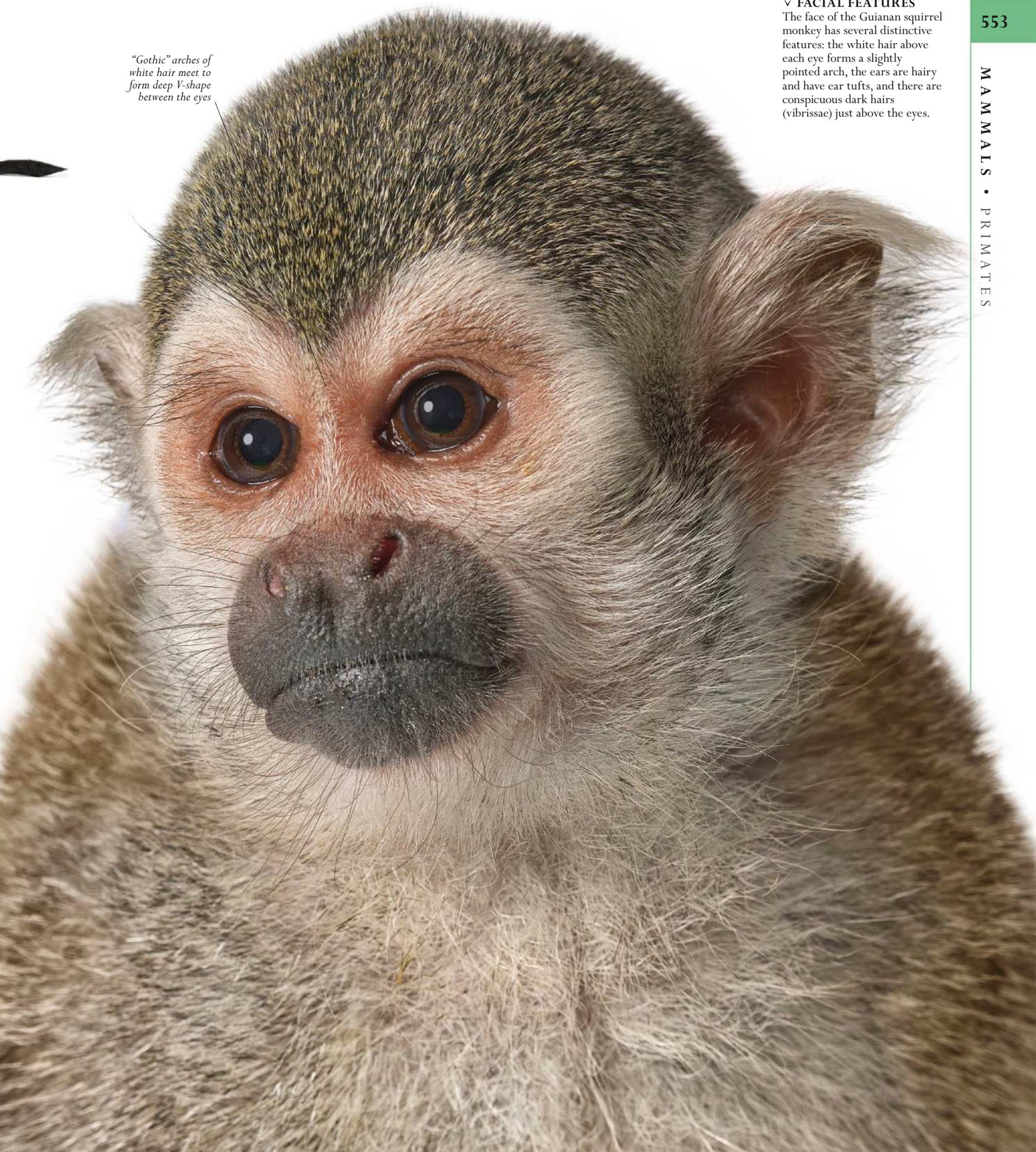
^ HAND
Although the hand is used to grip branches, hold food, self-groom, and perform other tasks, the fingers do not move independently, so the thumb and first finger cannot be opposed and used to pick things up.

^ TEETH
The Guianan squirrel monkey has 36 small, sharp teeth. The canines are longer and more prominent than the other teeth, and males have larger upper canines than females.

^ FOOT
Unlike the hand, the foot has a large, opposable digit – the big toe. When used in conjunction with the other four toes, it allows the foot to grasp branches.

BALANCING ACT >
The tail is at least as long as the head and body lengths combined. It is used to help with balance on tree branches as squirrel monkeys move on all fours.

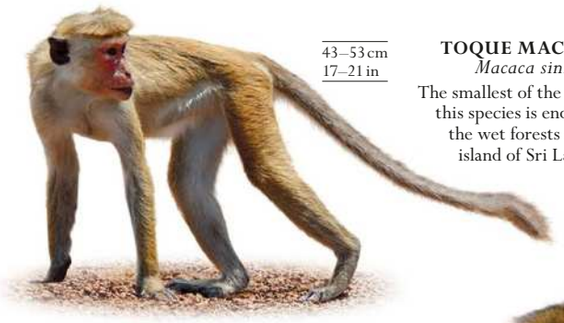
body covered by a short, thick coat



∨ FACIAL FEATURES
The face of the Guianan squirrel monkey has several distinctive features: the white hair above each eye forms a slightly pointed arch, the ears are hairy and have ear tufts, and there are conspicuous dark hairs (vibrissae) just above the eyes.

OLD WORLD MONKEYS

Widely distributed across Africa and Asia, the Cercopithecidae have closely spaced, downward-facing nostrils (catarrhine) and flattened nails. Most are diurnal and arboreal; however, baboons are mainly terrestrial. Guenons, baboons, and macaques are omnivorous, with strong jaws, cheek pouches, and a simple stomach. Colobus and leaf monkeys are leaf-eaters (folivorous) with a complex stomach, and lack cheek pouches.



43–53 cm
17–21 in

TOQUE MACAQUE
Macaca sinica
The smallest of the macaques, this species is endemic to the wet forests on the island of Sri Lanka.

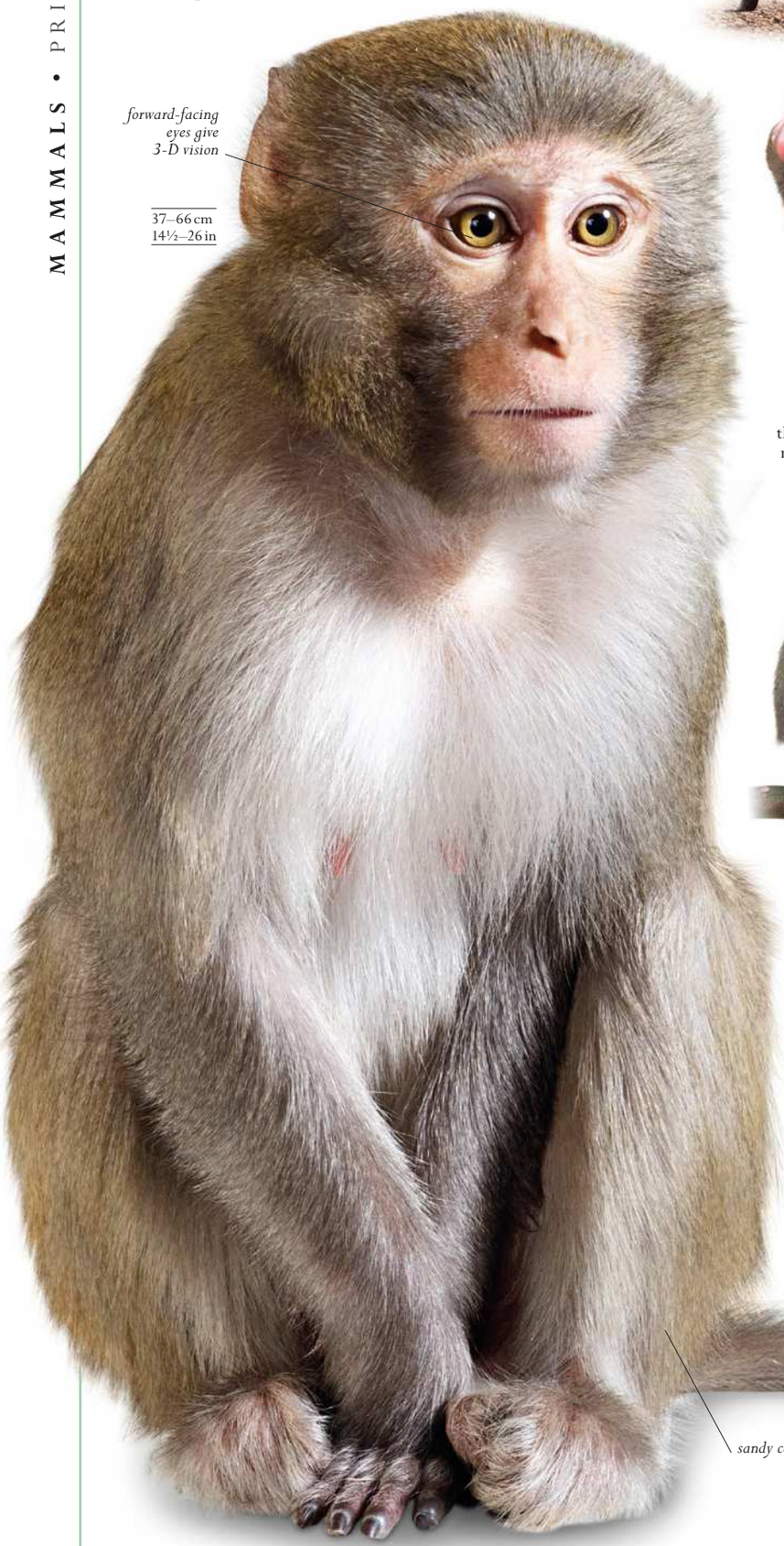
44–57 cm
17½–22½ in

CELEBES CRESTED MACAQUE
Macaca nigra
Endemic to Indonesia's Sulawesi Island, this monkey has bare, pink swellings on its rump. These become particularly swollen in females that are ready to mate.

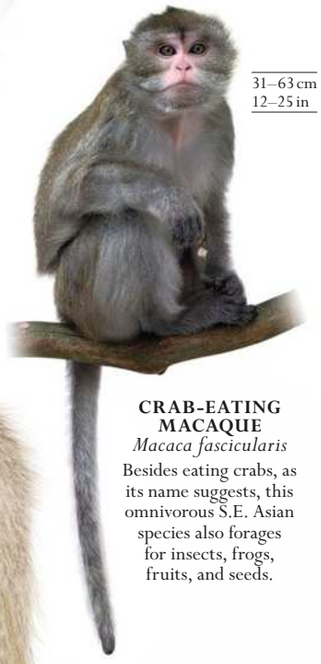
54–64 cm
21½–25 in

BARBARY MACAQUE
Macaca sylvanus
The only macaque outside Asia, the barbary macaque lives in the high cedar and oak forests of Algeria and Morocco.

forward-facing eyes give 3-D vision



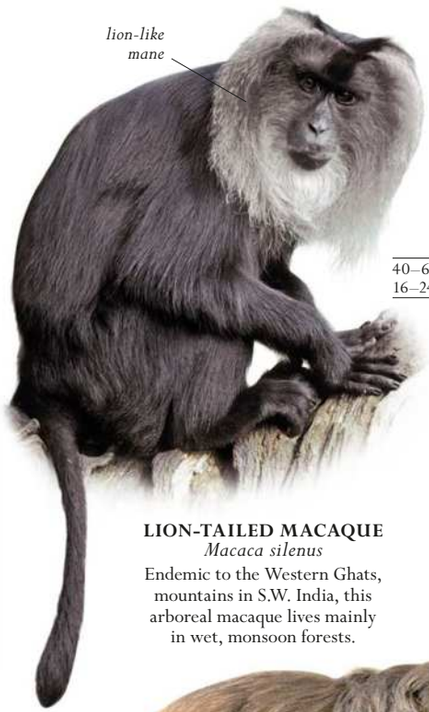
37–66 cm
14½–26 in



31–63 cm
12–25 in

CRAB-EATING MACAQUE
Macaca fascicularis
Besides eating crabs, as its name suggests, this omnivorous S.E. Asian species also forages for insects, frogs, fruits, and seeds.

lion-like mane



40–61 cm
16–24 in

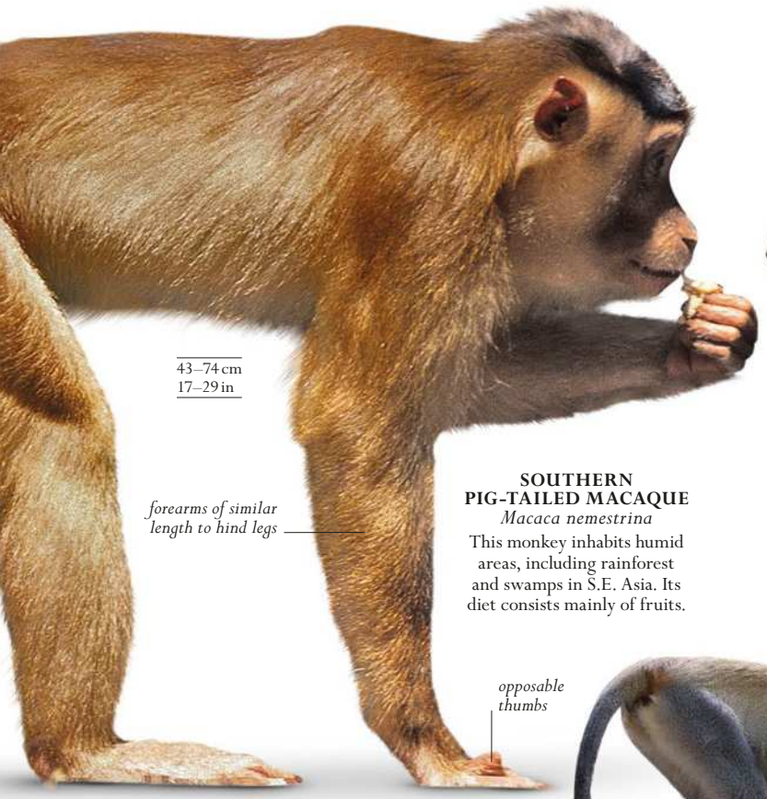
LION-TAILED MACAQUE
Macaca silenus
Endemic to the Western Ghats, mountains in S.W. India, this arboreal macaque lives mainly in wet, monsoon forests.

RHESUS MACAQUE
Macaca mulatta
This macaque lives in dry, open areas from W. Afghanistan through India to N. Thailand and China. Adults swim distances of up to 0.8 km (½ mile) between islands.

48–65 cm
19–26 in

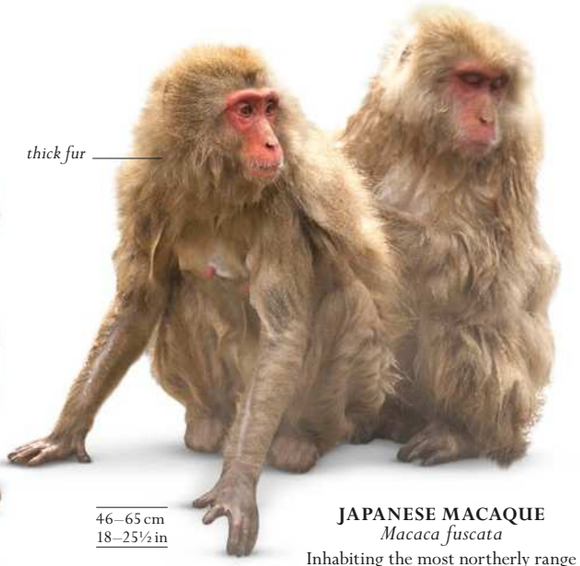
STUMP-TAILED MACAQUE
Macaca arctoides
Both arboreal and terrestrial, this species is found in tropical and subtropical wet forests in S.E. Asia.

sandy coloration

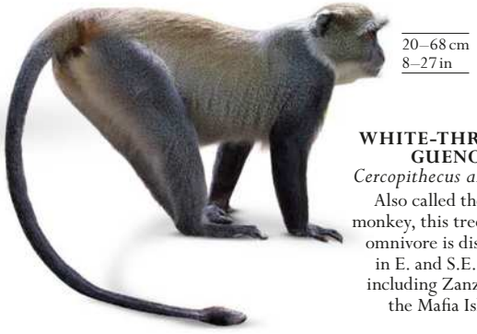


SOUTHERN PIG-TAILED MACAQUE
Macaca nemestrina
This monkey inhabits humid areas, including rainforest and swamps in S.E. Asia. Its diet consists mainly of fruits.

BONNET MACAQUE
Macaca radiata
Often found close to human habitation, this resident of S. India is omnivorous and may rely on humans for food.



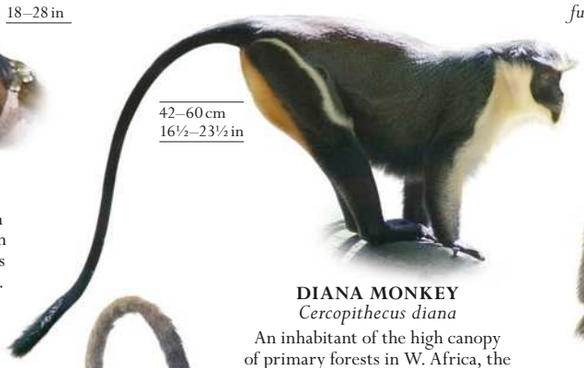
JAPANESE MACAQUE
Macaca fuscata
Inhabiting the most northerly range of any non-human primate, the Japanese macaque uses hot springs to keep warm in winter.



WHITE-THROATED GUENON
Cercopithecus albogularis
Also called the Sykes' monkey, this tree-dwelling omnivore is distributed in E. and S.E. Africa, including Zanzibar and the Mafia Islands.

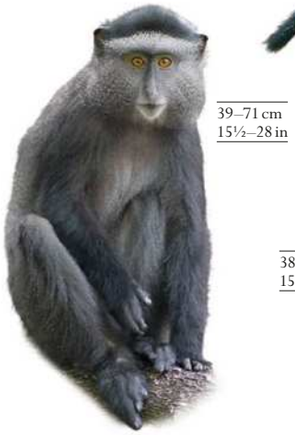
RED-TAILED MONKEY
Cercopithecus ascanius
An arboreal species of moist forest habitats in C. Africa, the red-tailed monkey has large cheek pouches, in which it stores fruits.

L'HOEST'S MONKEY
Allochrocebus lhoesti
Also known as the mountain monkey, this arboreal guenon lives in moist primary forests in the highlands of C. Africa.

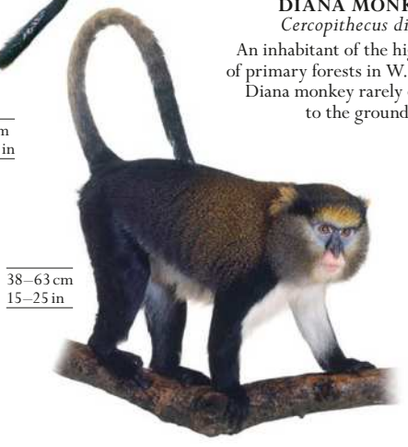


DIANA MONKEY
Cercopithecus diana
An inhabitant of the high canopy of primary forests in W. Africa, the Diana monkey rarely descends to the ground.

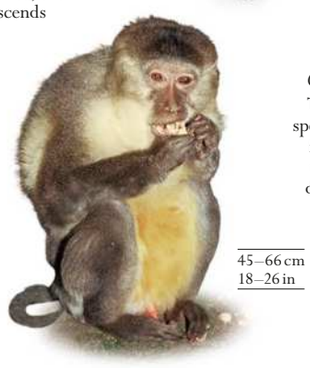
DE BRAZZA'S MONKEY
Cercopithecus neglectus
This is a semi-terrestrial species of C. African swamp forests. Males are larger than females and have a distinctive blue scrotum.



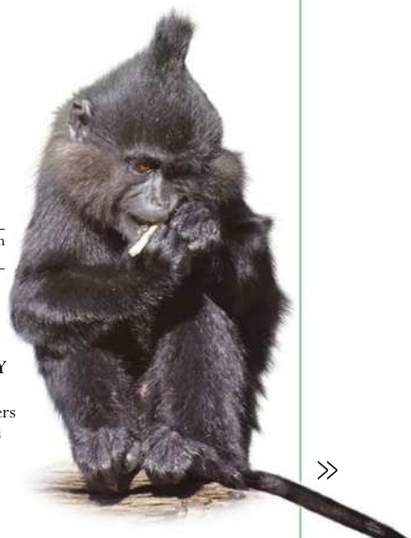
BLUE MONKEY
Cercopithecus mitis
Social groups of this African native number up to 40 individuals and consist of a dominant alpha male, several females, and their offspring.



MONA MONKEY
Cercopithecus mona
A tree-dwelling species, this monkey inhabits rainforest and mangrove forests from Ghana to Cameroon.



GOLDEN-BELLIED MANGABEY
Cercocebus chrysogaster
This mainly terrestrial mangabey lives in rainforest and swamp forest in the Congo basin. It forages by day in groups of up to at least 35 individuals.



NORTHERN BLACK-CRESTED MANGABEY
Lophocebus aterrimus
An arboreal species that prefers rainforest, this mangabey is found in the Democratic Republic of Congo.

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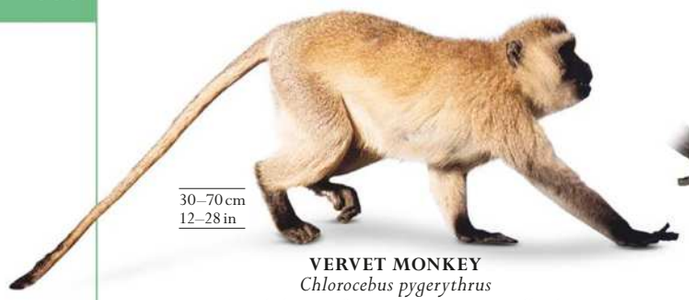
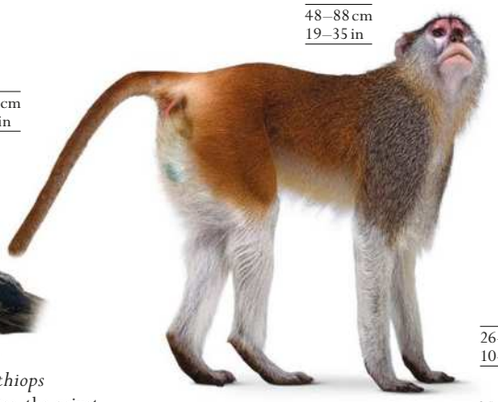


30–70 cm
12–28 in

VERVET MONKEY
Chlorocebus pygerythrus
An inhabitant of savanna and open woodland, this monkey is distributed from Ethiopia through E. Africa to South Africa.

40–66 cm
16–26 in

GRIVET
Chlorocebus aethiops
A semi-terrestrial species, the grivet lives in N.E. Africa. It is characterized by a green tinge on its upper face.



48–88 cm
19–35 in

PATAS MONKEY
Erythrocebus patas
The long limbs and short digits of this primate make it well-adapted for running. It is found from W. to E. Africa.

26–45 cm
10–18 in

ANGOLAN TALAPOIN
Miopithecus talapoin
The smallest of the Old World monkeys, the arboreal talapoin lives in wet and swampy forests in W. and C. Africa.

55–110 cm
22–43 in

MANDRILL
Mandrillus sphinx
Found in rainforest in western C. Africa, this species has distinctive facial markings that are duller in females and juveniles than in males.

45–83 cm
18–33 in

DRILL
Mandrillus leucophaeus
A large terrestrial monkey of lowland mature rainforest, the drill is found only in Cameroon, Nigeria, and the Republic of Equatorial Guinea.

50–90 cm
20–35 in

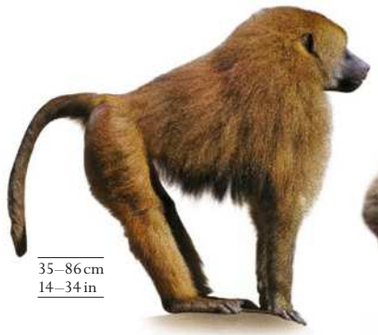
OLIVE BABOON
Papio anubis
This species forms troops of up to 100 baboons in the savanna and grassland steppe of central sub-Saharan Africa.

51–85 cm
20–34 in

YELLOW BABOON
Papio cynocephalus
An opportunistic baboon, this omnivore's diet includes seed pods, roots, insects, and other monkeys. It lives in S. and E. Africa.

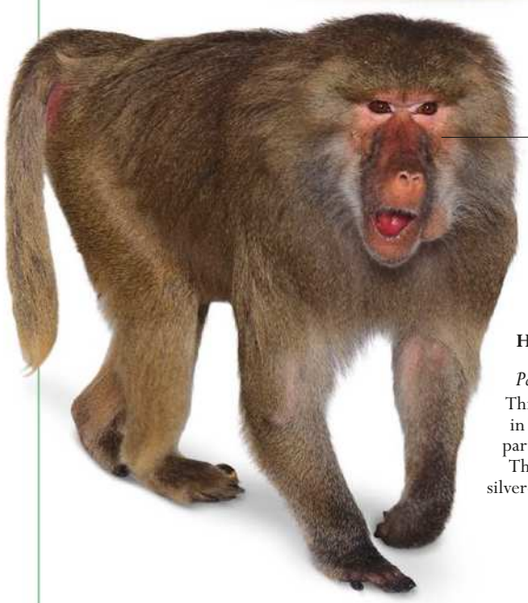
50–114 cm
20–43 in

CHACMA BABOON
Papio ursinus
One of the largest baboons, this species inhabits woodland, savanna, steppe, semi-desert, and montane habitats across southern Africa.



35–86 cm
14–34 in

GUINEA BABOON
Papio papio
One of the smallest baboons, this species also has one of the smallest ranges, confined to western equatorial Africa.

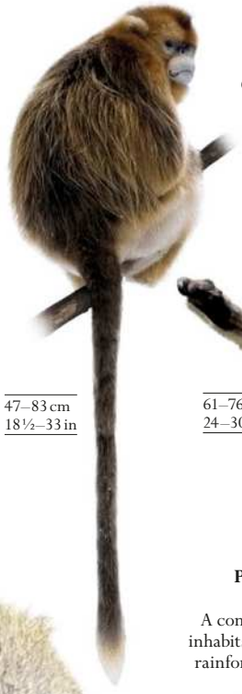


50–95 cm
20–37 in

HAMADRYAS BABOON
Papio hamadryas
This species is found in E. and C. Africa, particularly Ethiopia. The male has a long silver-grey shoulder cape.

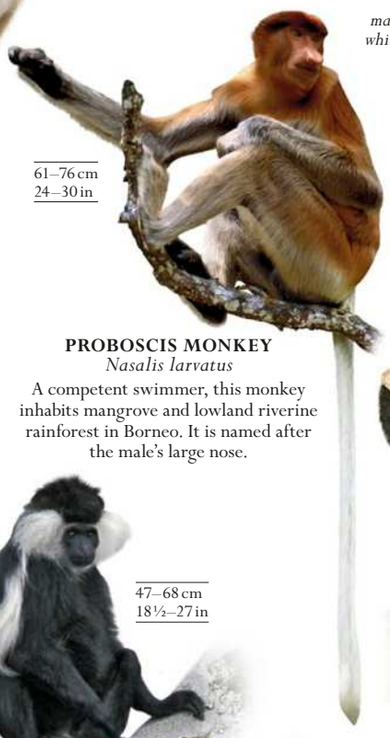
50–75 cm
20–30 in

GELADA
Theropithecus gelada
A grassland grazer from the highlands of Ethiopia, this primate has a distinctive bare patch of skin on its chest.



47–83 cm
18½–33 in

GOLDEN SNUB-NOSED MONKEY
Rhinopithecus roxellana
This monkey has thick fur, which helps it to survive in high montane forests in W. and C. China.

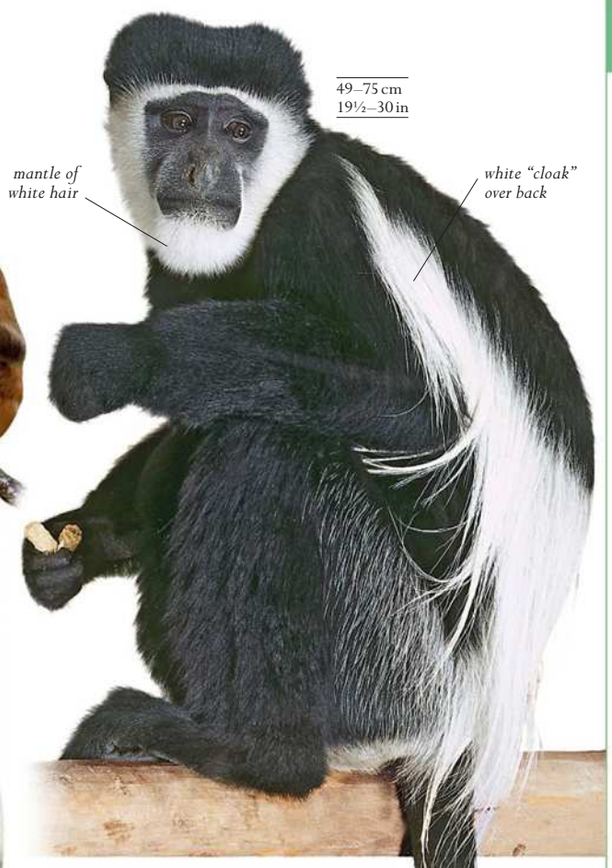


61–76 cm
24–30 in

PROBOSCIS MONKEY
Nasalis larvatus
A competent swimmer, this monkey inhabits mangrove and lowland riverine rainforest in Borneo. It is named after the male's large nose.

47–68 cm
18½–27 in

ANGOLA COLOBUS
Colobus angolensis
A predominantly arboreal species, this monkey inhabits a variety of forest habitats in Angola, Congo, and other neighbouring countries.



49–75 cm
19½–30 in

GUEREZA
Colobus guereza
Also called the eastern black-and-white colobus, this species is widespread in the moist tropical forests of C. and E. Africa.

41–78 cm
16–31 in

NORTHERN PLAINS GREY LANGUR
Semnopithecus entellus
Also called the Hanuman langur, this grey monkey is found in S. Asia, including India and Pakistan.

58–64 cm
23–25 in

TUFTED GREY LANGUR
Semnopithecus priam
Found in southeast India and Sri Lanka, this langur lives in many different habitats. Its diet consists mainly of tree foliage.

43–65 cm
17–26 in

JAVAN LANGUR
Trachypithecus auratus
Most males and females of this species are black in colour. However, some individuals retain their juvenile orange coloration into adulthood.

»

MANDRILL
Mandrillus sphinx

The mandrill is the largest of all monkeys, and the male is particularly spectacular. Mandrills live in troops that usually contain a dominant male, several females, a gaggle of youngsters, and various non-breeding, lower-ranking males. Sometimes several groups merge to form troops of 200 or more. Mandrill society has a strict hierarchy. Individuals advertise their status with colourful patches of skin on the face and rump. A dominant male is fearsome-looking, and he has a temperament to match. The brightness of the skin pigments is controlled by hormones and colour is a good indicator of strength and ferocity. A rival must be very sure of himself before challenging such a magnificent animal, and serious fights tend to occur only between well-matched individuals.

SIZE 55–110 cm (22–43 in)
HABITAT Dense rainforest
DISTRIBUTION Western Central Africa, from S. Cameroon to S.W Republic of Congo
DIET Mainly fruit

∨ LONG, HARD GLARE
Forward-facing eyes provide the mandrill with stereoscopic vision. They see in full colour, which helps them to locate ripe fruit and to distinguish the visual signals of other individuals.

< NOSTRILS
In a mature male, the skin around the nostrils and the centre of the snout is scarlet. Females and young mandrills have a black nose.

grooves on either side of the nose

< TEETH
The long canine teeth are used principally for fighting and in display. The cheek teeth are smaller, with knobbly surfaces, which are used for grinding up plant material.

∧ GRASP
Mandrill thumbs are short, but fully opposable – like those of the great apes – for grasping and manipulating objects. The fingers are long and very strong, with stout nails.

∧ HIND FEET
The hind feet resemble the hands, in that the toes are long and able to grasp. Mandrills are good climbers, and often sleep among the branches of trees.

∧ PLAIN RUMP
All mandrills have a hairless rump and a short tail. The rump of the subordinate male has less colour than the alpha male.

ALL FOURS >
Mandrills spend most of their time at ground level, where they move about on all fours, and typically roam 5–10 km (3–6 miles) a day.

ALPHA MALE >
The skin colour displayed by an individual changes depending on breeding condition and mood. The alpha male displays the most vivid red and blue hues on its face and rump.

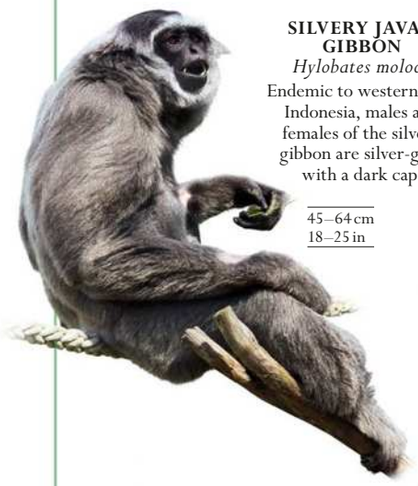
^ POWERFUL PROFILE
The mandrill's head is bulky, accommodating powerful jaw muscles needed to crush tough plant foods. Its ears are relatively small, though it has excellent hearing. Only high-ranking males have an orange beard.

GIBBONS

The gibbons, or lesser apes, of the family Hylobatidae are medium-sized fruit-eating primates. They have no tail and characteristically move by brachiation – swinging between trees using their very long forearms. Every day gibbon families sing to reinforce family and pair bonds and announce territorial ownership. Some species have an enlarged throat sac to amplify the sound.

AGILE GIBBON
Hylobates agilis
Although its coat coloration varies, all agile gibbons have white eyebrows, and males also have white cheeks. This species lives in Thailand, Indonesia, and Malaysia.

45–64 cm
18–25 in



SILVERY JAVAN GIBBON
Hylobates moloch
Endemic to western Java, Indonesia, males and females of the silvery gibbon are silver-grey with a dark cap.

45–64 cm
18–25 in

44–64 cm
17½–25 in

MÜLLER'S GIBBON
Hylobates muelleri
Also known as the grey gibbon, this species lives in Borneo. Monogamous pairs spend an average of 15 minutes per day singing duets.

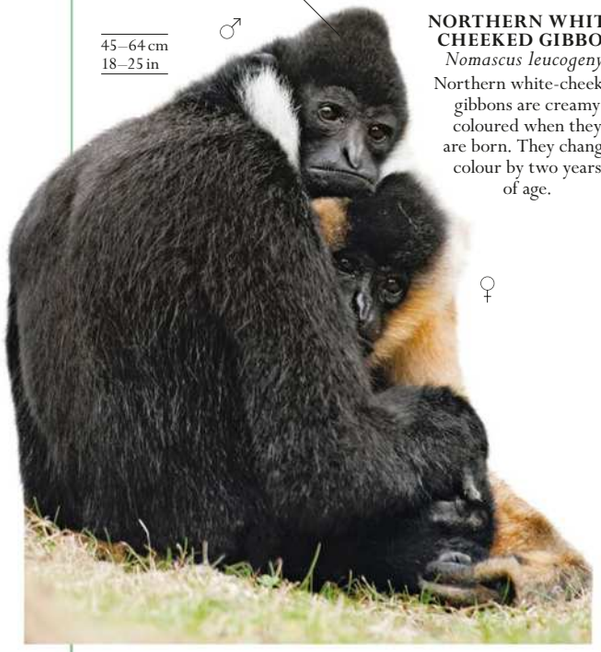
PILEATED GIBBON
Hylobates pileatus
Female pileated gibbons are silver-grey with a black face, chest, and cap; males are black. They are found in Thailand, Cambodia, and Laos.

44–64 cm
17½–25 in

81 cm
32 in

WESTERN HOOLOCK GIBBON
Hoolock hoolock
Male hoolock gibbons are black, but females are tan with dark brown cheeks. They are found in China, N.E. India, and N.W. Myanmar.

42–59 cm
16½–23 in

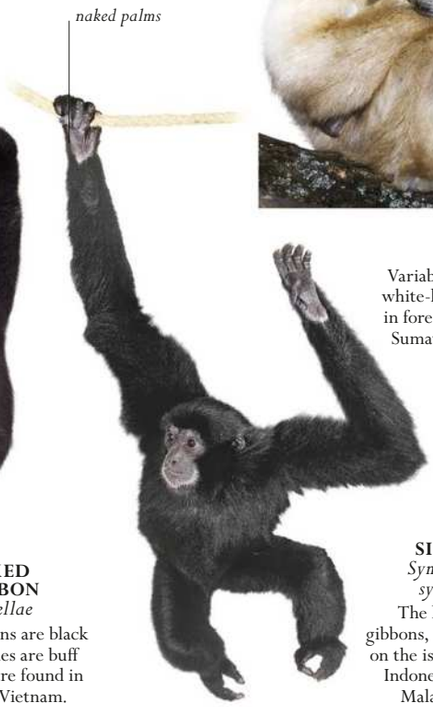


45–64 cm
18–25 in

NORTHERN WHITE-CHEEKED GIBBON
Nomascus leucogenys
Northern white-cheeked gibbons are creamy coloured when they are born. They change colour by two years of age.

45–64 cm
18–25 in

BUFF-CHEEKED CRESTED GIBBON
Nomascus gabriellae
Male buff-cheeked gibbons are black with pale cheeks; females are buff with a black cap. They are found in Cambodia, Laos, and Vietnam.



71–90 cm
28–35 in

SIAMANG
Symphalangus syndactylus
The largest of the gibbons, the siamang lives on the island of Sumatra, Indonesia, and on the Malay Peninsula.

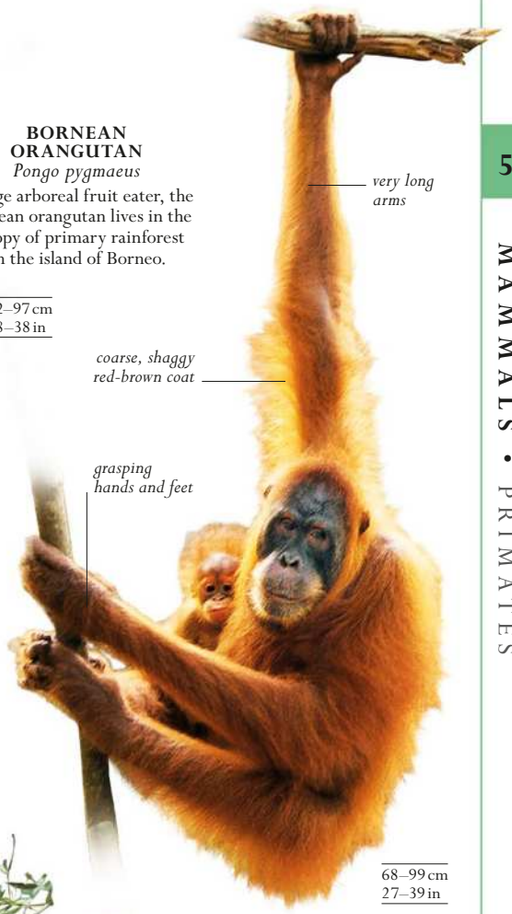
LAR GIBBON
Hylobates lar
Variable in coat coloration, the white-handed or lar gibbon lives in forests in Thailand, Malaysia, Sumatra, Myanmar, and Laos.

HUMANS AND APES

The family Hominidae contains the largest primates – the great apes and humans. Orangutans are arboreal, whereas chimpanzees, gorillas, and humans spend the majority of their time on the ground. Chimpanzees and gorillas move on all fours by "knuckle-walking". None of the great apes has a tail. Males are generally larger than females and all species have a relatively large braincase.

BORNEAN ORANGUTAN
Pongo pygmaeus
A large arboreal fruit eater, the Bornean orangutan lives in the canopy of primary rainforest on the island of Borneo.

72–97 cm
28–38 in

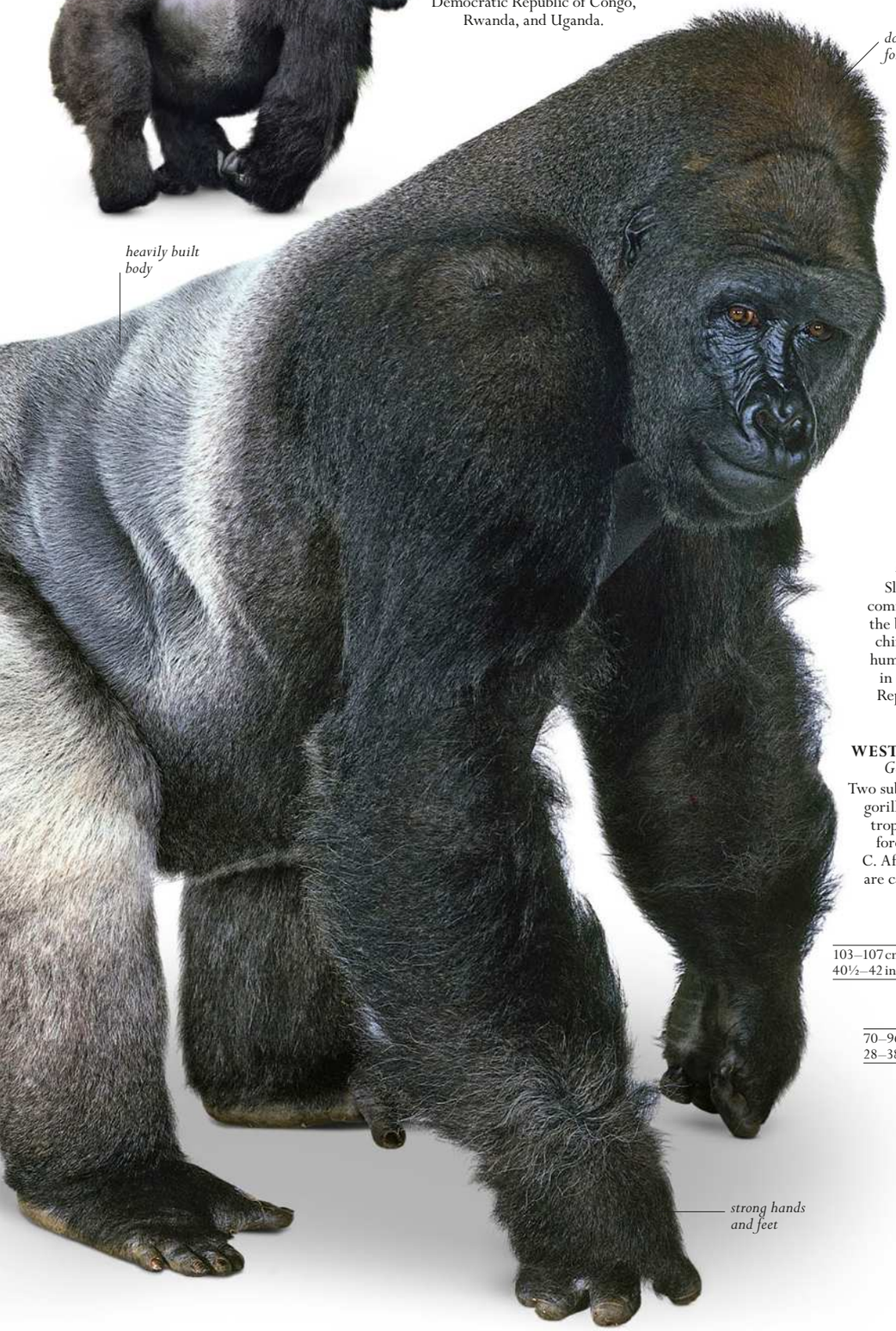


68–99 cm
27–39 in

SUMATRAN ORANGUTAN
Pongo abelii
The largest arboreal primate, the Sumatran orangutan is restricted to fragments of primary tropical forest in N. Sumatra.

101–120 cm
39–47 in

EASTERN GORILLA
Gorilla beringei
The largest primate, the two eastern gorilla subspecies inhabit montane cloud forest and lowland forest in the eastern Democratic Republic of Congo, Rwanda, and Uganda.

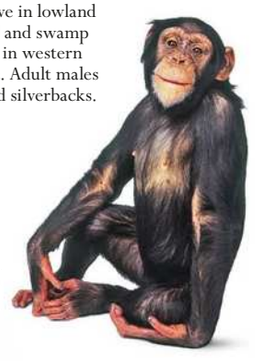


70–83 cm
28–33 in

BONOBO
Pan paniscus
Slighter than the common chimpanzee, the bonobo or pygmy chimpanzee lives in humid tropical forest in the Democratic Republic of Congo.

WESTERN GORILLA
Gorilla gorilla
Two subspecies of western gorilla live in lowland tropical and swamp forests in western C. Africa. Adult males are called silverbacks.

103–107 cm
40½–42 in



70–96 cm
28–38 in

COMMON CHIMPANZEE
Pan troglodytes
Four subspecies of the common chimpanzee are distributed in dry and moist forests and savanna woodlands in equatorial Africa.

1.2–2.1 m
4–7 ft

HUMAN
Homo sapiens
Characterized by a bipedal posture and a lack of body hair, humans permanently inhabit every terrestrial habitat, with the exception of Antarctica.

BATS

The only mammals capable of powered flight, bats are primarily nocturnal. Many species use echolocation to navigate and find food.

Bats are found worldwide in many different habitats, including tropical, subtropical, and temperate forests, savanna grasslands, deserts, and wetlands. Most fruit bats, as their name suggests, eat fruits. All other bats, once referred to as microbats, are mainly insect eaters. However, some bats drink nectar and eat pollen, a few suck blood, and some eat vertebrates, such as fish, frogs, and bats.

Their greatly elongated arm, hand, and finger bones support an elastic wing membrane for flight. Many bats also have a tail membrane between their legs. Bats typically rest upside down, hanging from their strong toes and claws.

THE SENSE OF ECHOLOCATION

Fruit bats rely predominantly on vision and smell, whereas microbats use a specialized sense called echolocation to avoid hitting objects, and to detect prey in the dark. They emit pulses of sound through their mouth or nose and form a "sound" image of their surroundings from returning echoes. Those species that emit echolocation calls through their nose usually have elaborate facial ornamentation, called noseleaves, for focusing the sound. Bats have very sensitive hearing, often highly tuned to the frequency of their returning echoes. Some species listen to prey-generated sounds, such as the rustle that an insect makes when walking on a leaf.

HABITS AND ADAPTATIONS

Bats are very social animals, living in colonies of hundreds or thousands and, exceptionally, millions of animals. They roost in trees and caves or in buildings, bridges, and mines. Temperate species either migrate to warmer climates or hibernate during winter. They may also become torpid if food becomes short in other seasons. Many interesting reproductive adaptations have developed, including the storage of sperm, delayed fertilization, and delayed implantation to ensure that the young are born at the optimum time of year.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CHIROPTERA
FAMILIES	21
SPECIES	About 1,400

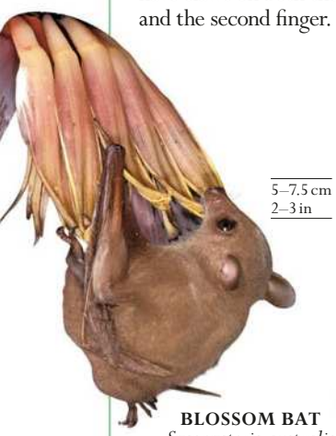
DEBATE

EVOLUTIONARY DEBATE

Morphological and genetic analyses of the relationships between bat families do not always agree with one another. Genetic studies suggest that all bats evolved from one common ancestor and that flight evolved only once. However, molecular studies, although still proposing two bat groups, also indicate that some echolocating bats, such as the horseshoe bats, are more closely related to non-echolocating fruit bats (Yinpterochiroptera) than to other echolocating microbats (Yangochiroptera) – an apparent conundrum unless echolocation has evolved twice or has later been lost in the fruit bats.

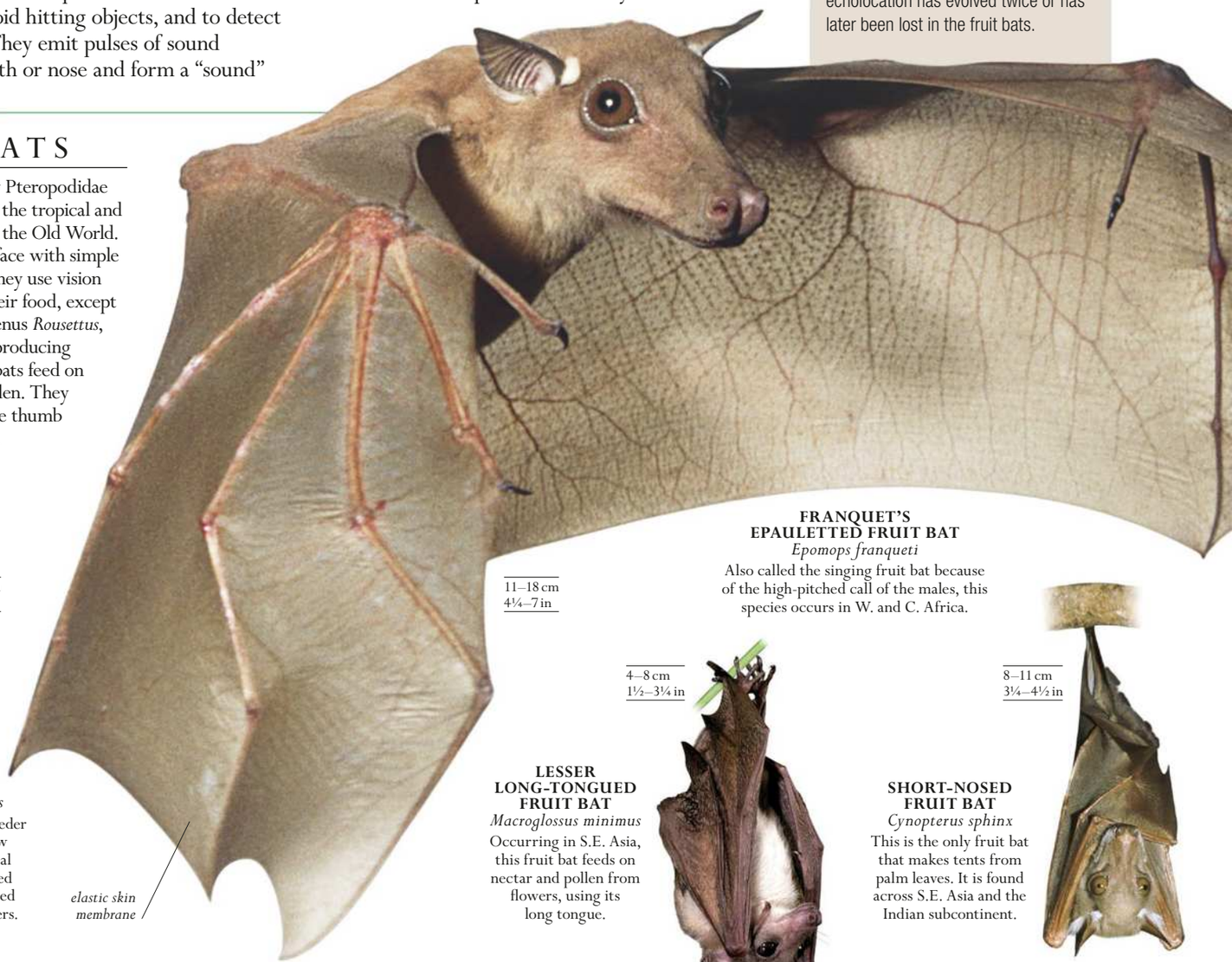
FRUIT BATS

The bats of the family Pteropodidae are distributed across the tropical and subtropical regions of the Old World. They have a dog-like face with simple ears and large eyes. They use vision and smell to locate their food, except for members of the genus *Rousettus*, which echolocate by producing tongue clicks. These bats feed on fruits, nectar, and pollen. They have claws on both the thumb and the second finger.



5–7.5 cm
2–3 in

BLOSSOM BAT
Syconycteris australis
This specialized nectar-feeder occurs from Papua New Guinea to eastern coastal Australia. It has a pointed muzzle and a brush-tipped tongue for probing flowers.



elastic skin membrane

11–18 cm
4¼–7 in

FRANQUET'S EPAULETTED FRUIT BAT
Epomops franqueti
Also called the singing fruit bat because of the high-pitched call of the males, this species occurs in W. and C. Africa.

4–8 cm
1½–3¼ in

LESSER LONG-TONGUED FRUIT BAT
Macroglossus minimus
Occurring in S.E. Asia, this fruit bat feeds on nectar and pollen from flowers, using its long tongue.

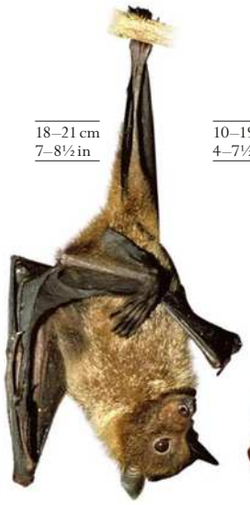
8–11 cm
3¼–4½ in

SHORT-NOSED FRUIT BAT
Cynopterus sphinx
This is the only fruit bat that makes tents from palm leaves. It is found across S.E. Asia and the Indian subcontinent.

13–20 cm
5–8 in

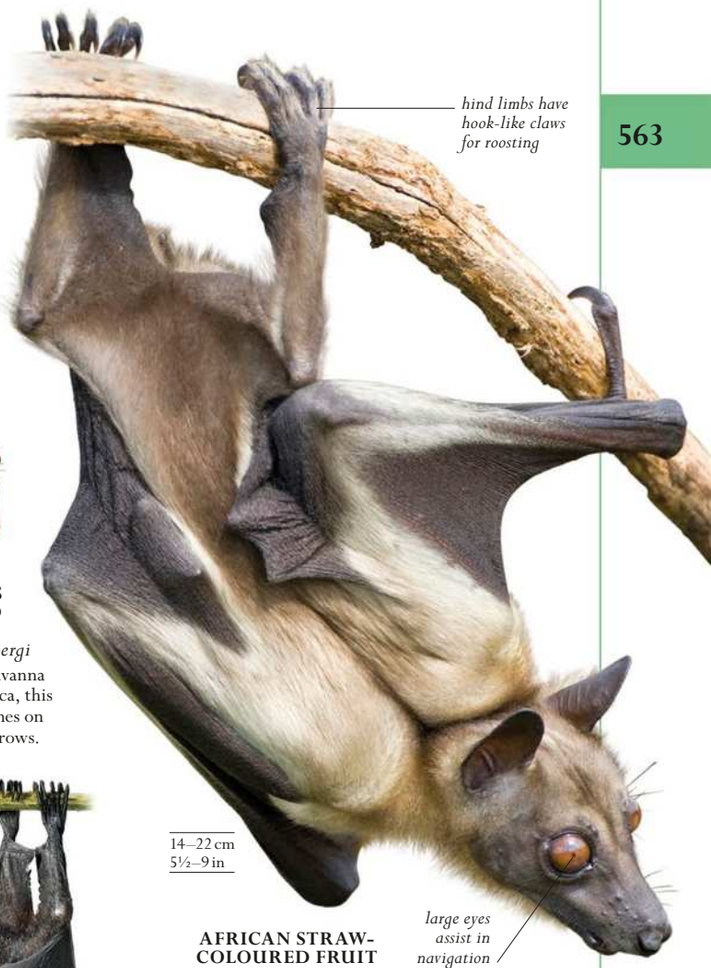
EGYPTIAN ROUSETTE
Rousettus aegyptiacus
Capable of echolocating by tongue clicks, this species occurs across Africa and the Middle East, except in the Sahara Desert.

12–16 cm
4¾–6½ in



18–21 cm
7–8½ in

10–19 cm
4–7½ in



hind limbs have hook-like claws for roosting

16–30 cm
6½–12 in

HAMMER-HEADED FRUIT BAT
Hypsignathus monstrosus
Males of this species are much larger than the females and have a greatly enlarged snout. This bat is found in W. and C. Africa.

GEOFFROY'S ROUSETTE
Rousettus amplexicaudatus
Like other *Rousettus* species, this S.E. Asian bat eats fruits and nectar. It roosts together with thousands of others in caves.

MOLUCCAN NAKED-BACKED FRUIT BAT
Dobsonia moluccensis
Widespread in the Moluccan Islands, this bat is rare in the far north of Australia.

WAHLBERG'S EPAULETTED FRUIT BAT
Epomophorus wahlbergi
Found in forests and savanna across sub-Saharan Africa, this species has white patches on its shoulders and eyebrows.

13–20 cm
5–8 in

15–20 cm
6–8 in

16–24 cm
6½–9½ in

14–22 cm
5½–9 in

large eyes assist in navigation

AFRICAN STRAW-COLOURED FRUIT BAT
Eidolon helvum
Colonies of this fruit bat can contain 1 million individuals. This migratory species is widespread in sub-Saharan Africa.

LITTLE RED FLYING FOX
Pteropus scapulatus
This nomadic species from Australia primarily feeds on eucalyptus blossoms. It is occasionally found in Papua New Guinea.

outstretched fingers

thick leg fur down to ankle

RODRIGUES FLYING FOX
Pteropus rodricensis
An inhabitant of mangrove and rainforest, this flying fox is found only on Rodrigues Island in the Indian Ocean.

LYLE'S FLYING FOX
Pteropus lylei
Occurring in Cambodia, Thailand, and Vietnam, the Lyle's flying fox can severely damage trees by stripping them of their leaves.

22–29 cm
9–11½ in

LARGE FLYING FOX
Pteropus vampyrus
The largest of all bats, this flying fox is found across the mainland and islands of S.E. Asia.

22–25 cm
9–10 in

INDIAN FLYING FOX
Pteropus medius
Found throughout India and parts of S.E. Asia, this species roosts in large colonies in forests and swamps.

18–28 cm
7–11 in

BLACK FLYING FOX
Pteropus alecto
The black flying fox has a wingspan of more than one metre. It lives in Indonesia, New Guinea, and N. Australia.

23–30 cm
9–12 in

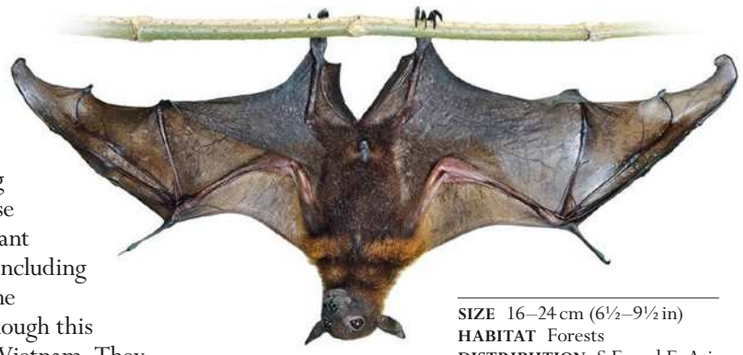
SPECTACLED FLYING FOX
Pteropus conspicillatus
This fruit bat inhabits primary and secondary tropical rainforests in Indonesia's Moluccan Islands, New Guinea, and N.E. Queensland, Australia.

23–29 cm
9–11½ in

GREY-HEADED FLYING FOX
Pteropus poliocephalus
The largest bat in Australia, this flying fox lives in communal roosts, known as camps, in rainforest and woodland.

LYLE'S FLYING FOX
Pteropus lylei

Lyle's flying fox is a medium-sized representative of the Old World fruit bat family, the Pteropodidae. Fruit bats are social animals; many hundreds may gather in roost trees during the day to rest and groom, dispersing at dusk to find ripe fruits. Although they may cause some damage to trees, many fruit bats are important pollinators and seed dispersers of tropical plants, including many commercial crops. Fruit bats are found in the tropical regions of Africa, Asia, and Australia, although this species is only found in Cambodia, Thailand, and Vietnam. They inhabit forested areas, including mangroves and fruit orchards.



SIZE 16–24 cm (6½–9½ in)
HABITAT Forests
DISTRIBUTION S.E. and E. Asia
DIET Fruits and leaves

all bats have a thumb claw, but only Old World fruit bats have a claw on the second finger too

∨ CANINE FACE
Fruit bats have large eyes for navigation and a large nose for sniffing out fruits, pollen, and nectar – giving them a dog-like face. Species that use echolocation have larger ears and smaller eyes.

< CLINGING CLAWS
Bats' sharp, curved claws are perfect for clinging on to tree branches. When roosting, tendons lock in place to ensure the bat's claws stay bent without the muscles needing to contract.

^ HAND WING
A bat's wing is formed of elongated forearm and finger bones supporting a thin elastic membrane attached to the sides of the body. It has a large surface area, giving lift in flight.

^ TAIL OR NO TAIL?
Pteropus bats lack a tail, but some have a partial membrane supported by cartilaginous spurs called calcars, which protrude from the ankle.

WALKING UPSIDE DOWN >
Fruit bats use their large clawed thumbs to help them move along the branches of their roost tree. The claw can also be used to manipulate fruit when feeding.

^ WELL WRAPPED
When resting, most fruit bats hang upside down with their leathery wings folded around their bodies. Bats roosting in the open risk overheating, so they flap their wings and cover themselves in saliva to help keep cool in hot weather.

reddish brown, foxy colouring

< HANGING AROUND
Few bats are able to move well on the ground, let alone take off from a flat surface. By hanging upside down they are able to take flight quickly. During the day, they hang upside down to sleep, nestled together for warmth.

large eyes are adapted for excellent vision, especially at night

upright, fox-like ears detect sounds beyond the range of human hearing

HORSESHOE BATS

Species of the family Rhinolophidae are distributed throughout southern Europe, Africa, Asia, and Australasia. Their noseleaf is characteristically horseshoe-shaped. They have the most sophisticated echolocation of all bats, involving highly specialized sound transmission and reception.

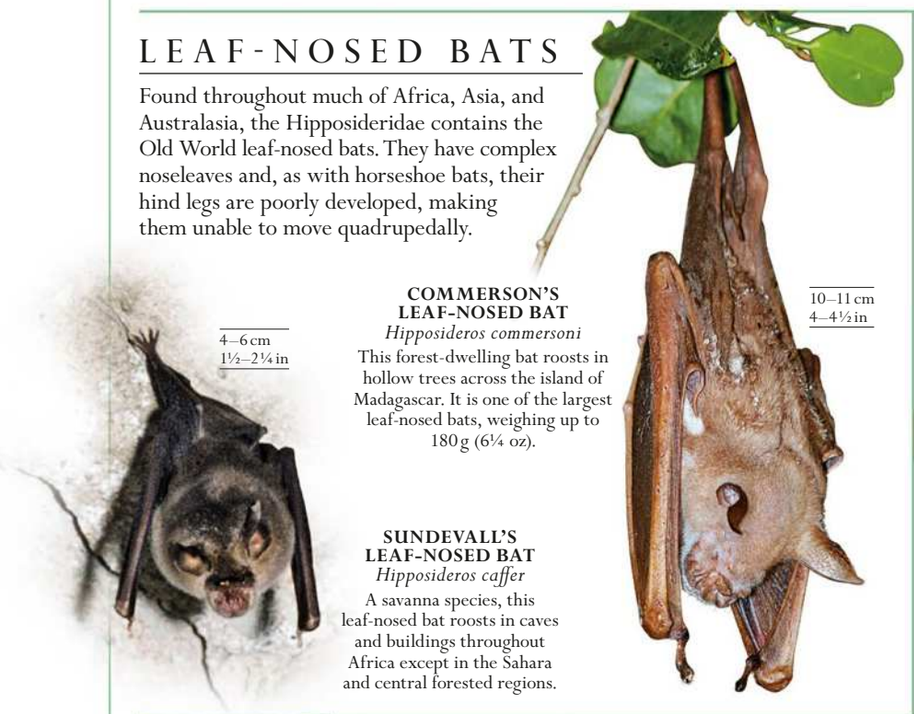
LESSER HORSESHOE BAT
Rhinolophus hipposideros
Found across Europe, N. Africa, and W. Asia, the lesser horseshoe bat is one of the smallest bats in the world.

MEHELY'S HORSESHOE BAT
Rhinolophus mehelyi
A cave-dwelling, medium-sized rhinolophid, this bat is patchily distributed across S. and E. Europe, and the Middle East.

GREATER HORSESHOE BAT
Rhinolophus ferrumequinum
The largest of the European horseshoe bats, this species' range extends from Europe eastwards across Asia to Japan.

LEAF-NOSED BATS

Found throughout much of Africa, Asia, and Australasia, the Hipposideridae contains the Old World leaf-nosed bats. They have complex noseleaves and, as with horseshoe bats, their hind legs are poorly developed, making them unable to move quadrupedally.

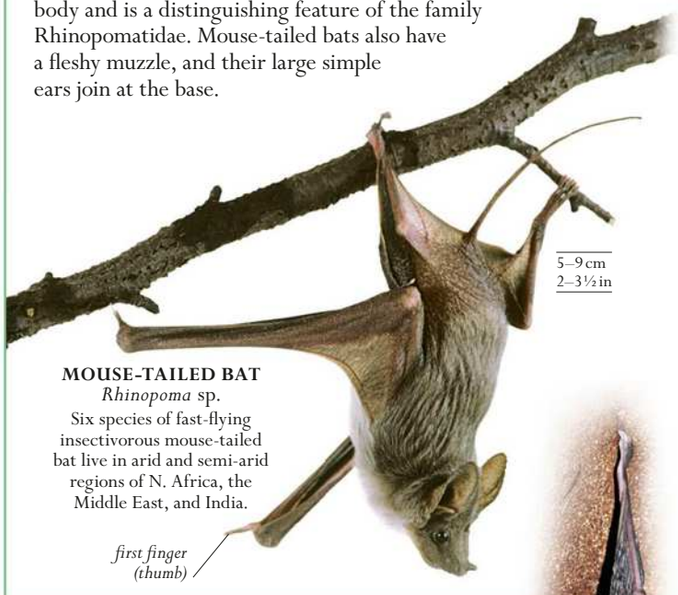


COMMERSON'S LEAF-NOSED BAT
Hipposideros commersoni
This forest-dwelling bat roosts in hollow trees across the island of Madagascar. It is one of the largest leaf-nosed bats, weighing up to 180 g (6¼ oz).

SUNDEVALL'S LEAF-NOSED BAT
Hipposideros caffer
A savanna species, this leaf-nosed bat roosts in caves and buildings throughout Africa except in the Sahara and central forested regions.

MOUSE-TAILED BATS

The tail of these bats is nearly as long as their body and is a distinguishing feature of the family Rhinopomatidae. Mouse-tailed bats also have a fleshy muzzle, and their large simple ears join at the base.



MOUSE-TAILED BAT
Rhinopoma sp.
Six species of fast-flying insectivorous mouse-tailed bat live in arid and semi-arid regions of N. Africa, the Middle East, and India.

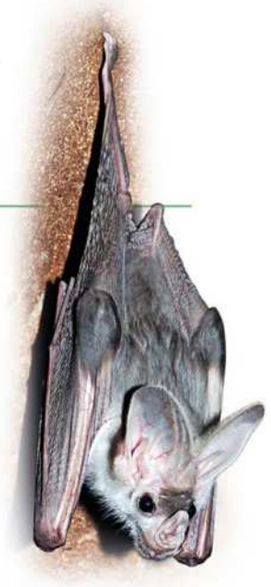
HOG-NOSED BAT

The sole member of the family Craseonycteridae, the tiny hog-nosed bat has long broad wings that allow it to hover. It lacks a tail and calcars (cartilaginous extensions of the ankle).

KITTI'S HOG-NOSED BAT
Craseonycteris thonglongyai
One of the world's smallest mammals, and often called the bumblebee bat, Kitti's hog-nosed bat lives in riverside caves in Thailand and Myanmar.

MEGADERMATIDAE

The family Megadermatidae comprises six fairly large echolocating bat species. Carnivorous and insectivorous, they have large ears and eyes and a broad tail membrane but little or no tail.



GHOST BAT
Macroderma gigas
Endemic to N. Australia, the ghost bat is one of the largest microbats. It preys on vertebrates, such as frogs and lizards.

SHEATH-TAILED BATS

The Emballonuridae are more commonly known as sheath-tailed bats because just the tip of their tail protrudes through the tail membrane, giving it the appearance of being sheathed. Many have glandular odour-storing sacs on their wings.

7.5–8.5 cm
3–3¼ in

HILDEGARDE'S TOMB BAT
Taphozous hildegardeae
Dependent on caves for roosting, Hildegarde's tomb bat feeds on insects in the coastal forests of Kenya and Tanzania.

4–5 cm
1½–2 in

LESSER SHEATH-TAILED BAT
Emballonura monticola
The short tail of this bat appears to retract into a sheath when it stretches its legs. It lives in Indonesia, Malaysia, Myanmar, and Thailand.

3.5–5 cm
1½–2 in

PROBOSCIS BAT
Rhynchonycteris naso
These bats spend the day roosting in groups on the underside of branches. They live in tropical forest in C. and S. America.

4.5–6 cm
2–2¼ in

GREATER SAC-WINGED BAT
Saccopteryx bilineata
Male greater sac-winged bats attract females by a pungent secretion in their wing sacs. The species is found in C. and S. America.

NEW WORLD LEAF-NOSED BATS

The Phyllostomidae contains species that are distributed from southwestern USA to northern Argentina. Most have large ears and a noseleaf, shaped like a spearhead, to enhance echolocation.

6.5–10 cm
2½–4 in

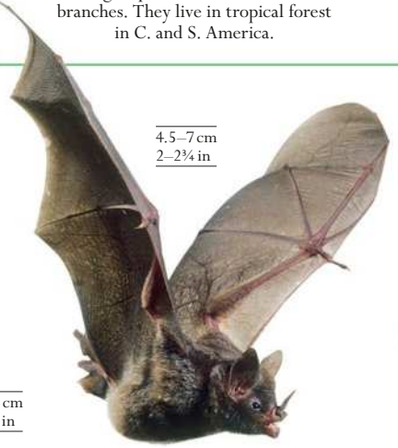
PALE SPEAR-NOSED BAT
Phyllostomus discolor
This species emits echolocation calls through its nose. It is found in C. and northern S. America.

5.5–7.5 cm
2¼–3 in

COMMON TENT-MAKING BAT
Uroderma bilobatum
Found in lowland forests from Mexico to central S. America, this bat creates shelters by biting palm and banana leaves.

4.5–6 cm
2–2¼ in

GERVAIS' FRUIT-EATING BAT
Artibeus cinereus
Preferring to roost in palm trees, Gervais' fruit-eating bat lives in S. America, including Venezuela, Brazil, and the Guianas.



4.5–7 cm
2–2¾ in

SEBA'S SHORT-TAILED BAT
Carollia perspicillata
Inhabiting moist evergreen and dry deciduous forests across much of C. and S. America, this species is a generalist fruit eater.

4.5–6 cm
2–2¼ in

SILKY SHORT-TAILED BAT
Carollia brevicaudum
This leaf-nosed bat is widespread in C. America and the Amazon region. It helps to restore degraded forests by dispersing the seeds of fruit trees.

8–10.5 cm
3¼–4¼ in

CALIFORNIAN LEAF-NOSED BAT
Macrotus californicus
Primarily hunting for moths by sight rather than echolocation, the Californian leaf-nosed bat lives in N. Mexico and the S.E. USA.

6–7.5 cm
2¼–3 in

GEOFFROY'S TAILLESS BAT
Anoura geoffroyi
A specialized nectar feeder, this species has a long muzzle, elongate cheek teeth, and a brush-tipped tongue. It lives in C. and S. America.

7–9.5 cm
2¾–3¾ in

FRINGE-LIPPED BAT
Trachops cirrhosus
The fringe-lipped bat catches frogs by listening for their calls. It lives in tropical forest in C. and northern S. America.

6–8 cm
2¼–3¼ in

WHITE-LINED BROAD-NOSED BAT
Platyrrhinus lineatus
Named for the white lines on its face and back, this broad-nosed bat roosts in damp forests of central S. America.

7–9.5 cm
2¾–3¾ in

COMMON VAMPIRE BAT
Desmodus rotundus
Famous for feeding on other mammals' blood, the common vampire bat occurs in a variety of habitats in Mexico and C. and S. America.

MORMOOPIDAE

The family Mormoopidae contains the naked-backed and moustache bats. Several species have wings that join across their back and they have a fringe of stiff hairs around the muzzle.

4.5–6 cm
2–2¼ in

DAVY'S NAKED-BACKED BAT
Pteronotus davyi
Unlike most other bats, this bat's wing membranes meet across its back. It is distributed from Mexico to S. America.

NOCTILIONIDAE

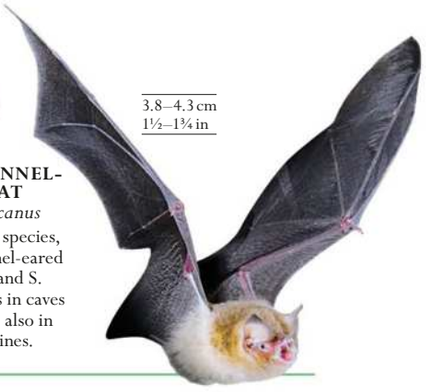
The two species of bulldog bats from the family Noctilionidae have long legs and large feet and claws. They have full lips and cheek pouches for storing food while flying.

8–10 cm
3¼–4 in

GREATER BULLDOG BAT
Noctilio leporinus
Specialized for snatching fish from the water's surface with its claws, the greater bulldog or fishing bat lives in tropical C. and S. America.

NATALIDAE

The funnel-eared bats of the family Natalidae are small and slender with large ears. Adult males have a sensory structure, called a natalid organ, on their forehead.



3.8–4.3 cm
1½–1¾ in

MEXICAN FUNNEL-EARED BAT
Natalus mexicanus
An insectivorous species, the Mexican funnel-eared bat lives in C. and S. America. It roosts in caves and, sometimes, also in abandoned mines.

SLIT-FACED BATS

The slit-faced bats of the family Nycteridae have a furrow from their nostrils to a pit between their eyes. The cartilage at the end of their tail ends in a "Y" shape.

6.5–7.5 cm
2½–3 in

MALAYAN SLIT-FACED BAT
Nycteris tragata
The facial furrow of this slit-faced bat helps to direct its echolocation calls. It is found in tropical forest in Myanmar, Malaysia, Sumatra, and Borneo.

MYSTACINIDAE

The one extant member of the Mystacinidae has extra talons on its thumb and toe claws. Its tough, leathery wings can be folded against the body when moving on the ground.

6–8 cm
2¼–3¼ in

LESSER NEW ZEALAND SHORT-TAILED BAT
Mystacina tuberculata
An agile mover on the ground, the New Zealand short-tailed bat sniffs out prey in leaf litter on the forest floor.

THYROPTERIDAE

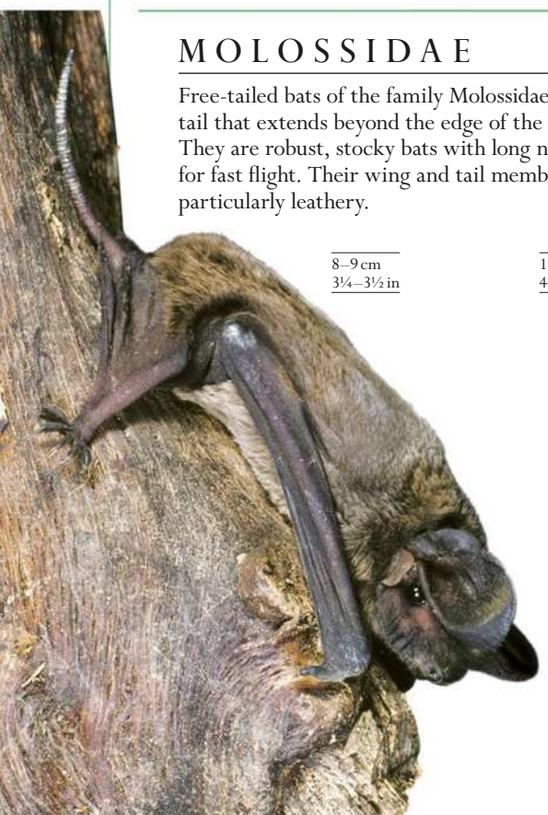
The family Thyropteridae contains five species of disk-winged bats. Suction cups on the wrists and ankles allow them to attach to smooth-surfaced tropical leaves when roosting.

4–5 cm
1½–2 in

SPIX'S DISK-WINGED BAT
Thyroptera tricolor
An insectivorous inhabitant of lowland forests from S. Mexico to S.E. Brazil, Spix's disk-winged bat roosts head upwards inside furled leaves.

MOLOSSIDAE

Free-tailed bats of the family Molossidae have a distinctive tail that extends beyond the edge of the tail membrane. They are robust, stocky bats with long narrow wings for fast flight. Their wing and tail membranes are particularly leathery.



8–9 cm
3¼–3½ in

11–14 cm
4½–5½ in

LARGE-EARED FREE-TAILED BAT
Otomops martiensseni
This African species, like the European free-tailed bat, has exceptionally low-frequency echolocation calls, which are clearly audible to humans.

4.5–6.5 cm
2–2½ in

BRAZILIAN FREE-TAILED BAT
Tadarida brasiliensis
Colonies of the Mexican free-tailed bat roosting in caves and beneath bridges in Texas and Mexico can number in the millions.

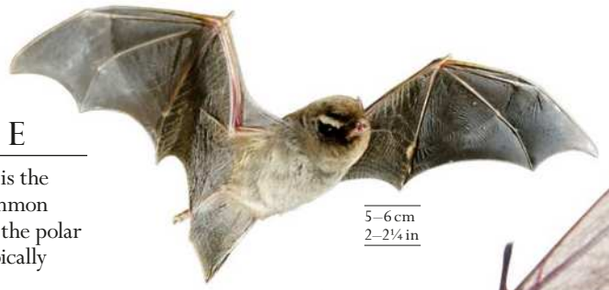
EUROPEAN FREE-TAILED BAT
Tadarida teniotis
The only free-tailed bat to live in Europe, this bat's range extends from the Mediterranean to S. and S.E. Asia.

7–8 cm
2¾–3¼ in

MILLER'S MASTIFF BAT
Molossus pretiosus
An insectivorous bat of lowland dry forests, open savanna, and cactus scrub, Miller's mastiff bat is distributed from Mexico to Brazil.

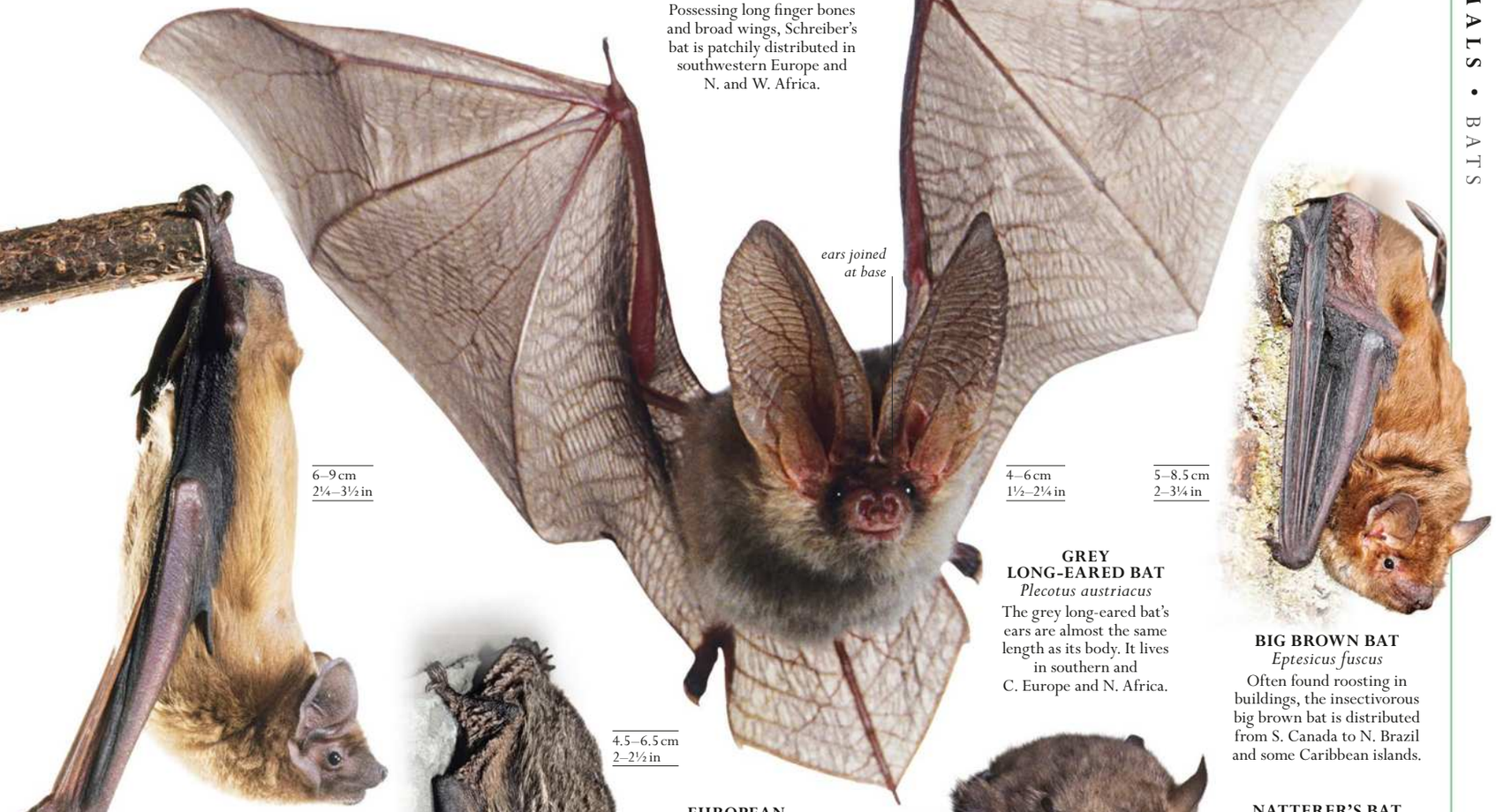
VESPERTILIONIDAE

Consisting of 496 species, the Vespertilionidae is the largest family of bats. Known as evening or common bats, they are distributed worldwide excluding the polar regions, and are mostly insectivorous. They typically have a plain nose and small eyes.



5–6 cm
2–2¼ in

SCHREIBER'S BENT-WINGED BAT
Miniopterus schreibersii
Possessing long finger bones and broad wings, Schreiber's bat is patchily distributed in southwestern Europe and N. and W. Africa.



6–9 cm
2¼–3½ in

4–6 cm
1½–2¼ in

5–8.5 cm
2–3¼ in

GREY LONG-EARED BAT
Plecotus austriacus
The grey long-eared bat's ears are almost the same length as its body. It lives in southern and C. Europe and N. Africa.

BIG BROWN BAT
Eptesicus fuscus
Often found roosting in buildings, the insectivorous big brown bat is distributed from S. Canada to N. Brazil and some Caribbean islands.

COMMON NOCTULE
Nyctalus noctula
A fast and powerful flier with narrow, blackish-brown wings, the noctule is found across N.E. Europe and parts of Asia.

4.5–6.5 cm
2–2½ in

EUROPEAN PARTICOLOURED BAT
Vespertilio murinus
This pale-bellied, dark-backed bat is native to mountain, steppe, and forest habitats from E. and C. Europe to Asia. It is also found in urban areas.

4–5 cm
1½–2 in

NATTERER'S BAT
Myotis nattereri
From N.W. Africa, across Europe to S.W. Asia, Natterer's bat catches insects in its fringed tail membrane during a slow, hovering flight.

4–5 cm
1½–2 in

3.5–5.5 cm
1½–2¼ in

EASTERN PIPISTRELLE
Perimyotis subflavus
The eastern pipistrelle hibernates in rock crevices, mines, and caves during winter. Its range covers eastern N. America, from S. Canada to N. Honduras.

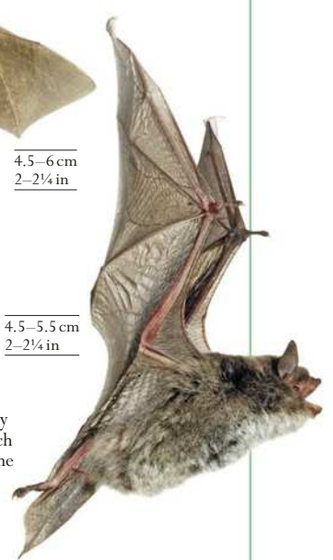
COMMON PIPISTRELLE
Pipistrellus pipistrellus
The most widespread pipistrelle species, the common pipistrelle's range extends from W. Europe to the Far East and N. Africa.

4.5–5.5 cm
1¾–2¼ in

NATHUSIUS' PIPISTRELLE
Pipstrellus nathusii
A long-distance migrant capable of journeys of over 1,900 km (1,200 miles) in spring and autumn, this species mainly occurs in E. and C. Europe.

FRINGED MYOTIS
Myotis thysanodes
Named after a fringe of hairs along the edge of its tail membrane, this myotis bat lives in western N. America.

4.5–6 cm
2–2¼ in



4.5–5.5 cm
2–2¼ in

DAUBENTON'S BAT
Myotis daubentonii
This Eurasian bat has relatively large feet, which help it to catch flying insects emerging from the surface of bodies of water.

HEDGEHOGS, MOLES, AND RELATIVES

Four families in two orders have recently been grouped together in a new order Eulipotyphla, which means "truly fat and blind". All of its members are small, long-snouted, primarily insectivorous mammals.

The four families in the Eulipotyphla are the Erinaceidae (hedgehogs and gymnures), Solenodontidae (solenodons), Talpidae (moles and desmans), and Soricidae (shrews). Most species of Erinaceidae have spines – only the gymnures have fur – and are predominantly terrestrial and nocturnal. The Solenodontidae is the smallest family but contains the two largest species, both of which live on Caribbean islands. The Talpidae is the most diverse of the four families, comprising 54 species and including several types of burrowing mole and the sub-aquatic desmans. The Soricidae is the largest family, containing about 450 species, including one of the smallest of all mammals, the Etruscan shrew.

VENOMOUS SALIVA

Well adapted to their insectivorous way of life, the long, mobile, cartilaginous snout of shrews, moles, desmans, and solenodons contains numerous simple, sharp-pointed teeth, which they use to catch and kill prey, such as earthworms, other invertebrates, and small vertebrates. Some species produce venomous saliva, which in solenodons runs along a groove in one of their lower incisor teeth and helps to subdue larger prey before it is killed. By contrast, hedgehogs do not produce toxic saliva but some are immune to snake venom.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	EULIPOTYPHLA
FAMILIES	4
SPECIES	530

Immunity to snake venom allows a hedgehog to take advantage of any snake it comes across as a potential food source.

HEDGEHOGS AND GYMNURES

With a long, sensitive snout and a short, hairy tail, members of the family Erinaceidae eat almost anything, from invertebrates and fruit to birds' eggs and carrion. The hedgehogs, from Eurasia and Africa, are covered in sharp protective spines, while the southeast Asian gymnures have normal hair and look more like rats or opossums. Gymnures (also called moonrats) have especially well-developed scent glands that exude a strong garlic-like odour for marking territories.

17–19 cm
6½–7½ in

SOUTHERN AFRICAN HEDGEHOG
Atelerix frontalis
Inhabiting grassland, scrub, and gardens in southern Africa, this species has a white band across its forehead, contrasting with its dark face.

20–27 cm
8–10½ in

NORTH AFRICAN HEDGEHOG
Atelerix algirus
Found in varied habitats in the Mediterranean region, this long-legged hedgehog with a pale face and underparts has a spineless "parting" on its crown.

WEST EUROPEAN HEDGEHOG
Erinaceus europaeus
Found throughout W. Europe, this species inhabits woodland, farmland, and gardens. In cooler areas, it hibernates in a nest of leaves and grass.

20–25 cm
8–10 in

pale spines with darker bands

14–26 cm
5½–10 in

AFRICAN PYGMY HEDGEHOG
Atelerix albiventris
Because the innermost digit of the hind feet is reduced or absent, this species is also known as the four-toed hedgehog.

13–24 cm
5–9½ in

DESERT HEDGEHOG
Paraechinus aethiopicus
This small African and Middle Eastern hedgehog is immune to the venom of snakes and scorpions, which form a large part of its diet.

DEBATE
FAMILY RELATIONS

Molecular analyses of the Eulipotyphla families suggest that they share a common ancestor and so form a natural group. The results also indicate that the shrews are more closely related to the hedgehogs and gymnures than to the talpids and solenodons as was previously thought. However, the relationship of the talpids to the shrews and hedgehogs and gymnures has yet to be resolved.

SOLENODONS

The Solenodontidae are the oldest extant lineage of the group and are thought to have separated from other Eulipotyphla about 75 million years ago. They have an elongated, flexible, cartilaginous snout; a long, naked, scaly tail; small eyes; and coarse, dark fur. Unusually among mammals, they also have venomous saliva, which is used to subdue prey ranging from invertebrates to small reptiles.

27–49 cm
10½–19½ in

HISPANIOLAN SOLENODON
Solenodon paradoxus

One of two extant species in its family, this solenodon is known only on Hispaniola, an island to the east of Cuba in the Caribbean.

CUBAN SOLENODON
Solenodon cubanus

With longer, finer fur than its Hispaniolian relative, this secretive, nocturnal burrower was erroneously believed to be extinct during the 20th century.

20–36 cm
8–14 in

16–28 cm
6½–11 in

COMMON LONG-EARED HEDGEHOG
Hemiechinus auritus

Long ears help radiate heat and keep this nocturnal hedgehog cool in the deserts of N. Africa and C. Asia.

25–46 cm
10–18 in

MOONRAT
Echinosorex gymnurus

Resembling a large rat, the nocturnal, white-coated moonrat lives in swamps and other wet habitats in Malaysia.

9–16 cm
3½–6½ in

SHORT-TAILED GYMNURE
Hylomys suillus

Usually solitary, this S.E. Asian gymnure lives in forested areas with dense undergrowth. It uses its long, mobile snout to find invertebrate prey but will also eat fruits.

MOLES AND DESMANS

Small, dark insectivores with a cylindrical body, short, dense fur, and a very sensitive, hairless, tubular snout, moles of the family Talpidae are well adapted for a life of burrowing – the forelegs have powerful claws, and the hands are turned permanently outwards in the form of a shovel. In contrast, the aquatic desmans have webbed paws fringed with stiff hairs and a long, flattened tail to aid in swimming.

STAR-NOSED MOLE
Condylura cristata

A semi-aquatic N. American mole, this species has 11 pairs of pink fleshy appendages around its snout, which detect prey by touch.

9.5–13 cm
3¾–5 in

11–16 cm
4¼–6½ in

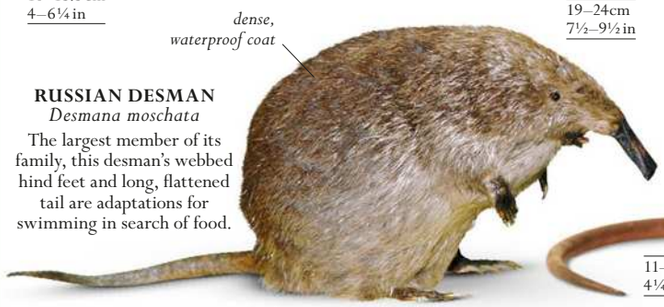
EUROPEAN MOLE
Talpa europaea

Secretive due to its burrowing lifestyle, this mole creates extensive networks of permanent tunnels, often marked by distinctive surface mole-hills.

10–15.5 cm
4–6¼ in

SMALL JAPANESE MOLE
Mogera imaizumii

This small mole from Japan is found in soft, deep soils, and is distinguished from close relatives by dental features.



19–24cm
7½–9½ in

RUSSIAN DESMAN
Desmana moschata

The largest member of its family, this desman's webbed hind feet and long, flattened tail are adaptations for swimming in search of food.

11–16 cm
4¼–6½ in

PYRENEAN DESMAN
Galemys pyrenaicus

Feeding in Pyrenean mountain streams, this desman rarely digs burrows; it shelters in rock crevices or the holes of water voles.

13–15.5 cm
5–6¼ in

EASTERN MOLE
Scalopus aquaticus

A burrowing mole from N. America, typically in moist sandy soils, this species has ears and eyes covered by skin and fur respectively.

SHREWS

With a pointed snout, velvety fur, a long tail, and sharp, simple teeth, members of the Soricidae are largely insectivorous, but also eat seeds, fruits, and carrion. Mostly terrestrial, they are highly active, needing to eat at least 80 per cent of their own body weight daily. They have poor vision, but excellent senses of hearing and smell, and use echolocation to find their way around.

LESSER WHITE-TOOTHED SHREW
Crocidura suaveolens
Like others in its genus, this European species lacks the iron deposits that produce red tips on the teeth of many shrews.

4.5–8 cm
2–3¼ in

6.5–9.5 cm
2½–3¾ in

REDDISH-GREY SHREW
Crocidura cyanea
Males of this southern African forest shrew use a strong musky scent to mark their territories.

pale feet

9–16 cm
3½–6½ in

HOUSE SHREW
Suncus murinus
Native to S. Asia but introduced elsewhere in Asia and Africa, this adaptable, uniformly grey-brown shrew is often associated with human habitation.

5–7 cm
2–2¾ in

3.5–5 cm
1½–2 in

9–11.5 cm
3½–4¾ in

CRAWFORD'S GREY SHREW
Notiosorex crawfordi
From arid parts of N. America, this shrew can survive without water. To conserve fluid, it produces highly concentrated urine.

NORTHERN SHORT-TAILED SHREW
Blarina brevicaudus
This large and venomous N. American species usually forages in tunnels or under leaf litter or snow, rather than above ground.

ETRUSCAN SHREW
Suncus etruscus
One of the smallest living mammals, weighing only 2 g (1/16 oz), this shrew occurs in S. Europe and the Middle East, with closely related forms in Asia.

5.5–8 cm
2¼–3¼ in

COMMON SHREW
Sorex araneus
The most common shrew in N. Europe, it is active day and night throughout the year, searching for food.

6–7.5 cm
2¼–3 in

PYGMY SHREW
Sorex minutus
Smaller than the common shrew, with which it often occurs, this species is distinguished by its relatively longer and hairier tail.

4–6.5 cm
1½–2½ in

ALPINE SHREW
Sorex alpinus
The tail of this dark C. European shrew is as long as its head and body. It aids balance when climbing trees.

short, dense, velvety fur

5–7 cm
2–2¾ in

EURASIAN WATER SHREW
Neomys fodiens
The stiff hairs on its feet and tail improve the swimming efficiency of this large, sharply bicoloured shrew, which hunts mainly in water.

7.5–10.5 cm
3–4¼ in

NORTH AMERICAN LEAST SHREW
Cryptotis parvus
A ferocious hunter, this species tackles a variety of prey. It also bites the tail of lizards, which when shed provides an easy meal.

PANGOLINS

With a body covered in large keratin scales, pangolins are also known as scaly anteaters, reflecting their appearance and diet.

Mainly nocturnal and with small eyes, pangolins use their excellent sense of smell to find food. Although somewhat similar in appearance to the American armadillos, and sharing a similar diet, pangolins belong to a different order, Pholidota, and are most closely related to the carnivores.

The horny scales, which cover all exposed parts of the body, can make up one fifth of a pangolin's body weight: despite this, they are excellent swimmers. There are both terrestrial and arboreal species: ground-dwellers live in deep burrows, while tree-dwellers live in holes in trees.

Pangolins have powerful claws that are used to excavate insect nests. Food is captured on the sticky tongue, which extends up to 40 cm (16 in) from the toothless mouth. Because of the size of their front claws, pangolins walk on their wrists, the forepaws curled over to protect the claws.

SAFE FROM ATTACK

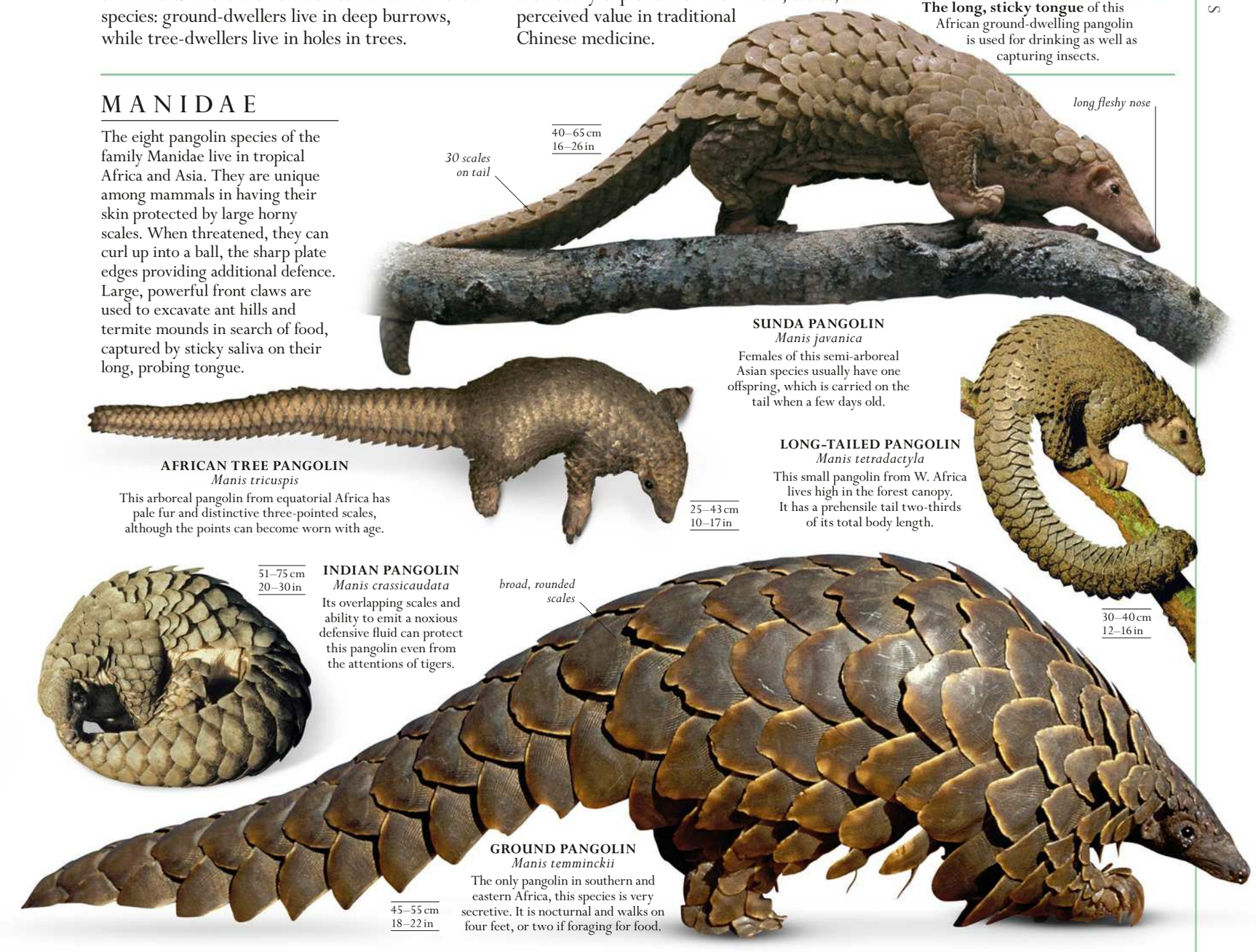
The role of the scaly coat is as protection against predators, enhanced by the tendency of pangolins to roll into a ball when threatened or sleeping. Further defence is provided by their ability to emit a foul-smelling chemical from their anal glands, which is also used to mark territory. Nevetheless, pangolins are heavily exploited for their meat, scales, and perceived value in traditional Chinese medicine.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PHOLIDOTA
FAMILIES	1
SPECIES	8

The long, sticky tongue of this African ground-dwelling pangolin is used for drinking as well as capturing insects.

MANIDAE

The eight pangolin species of the family Manidae live in tropical Africa and Asia. They are unique among mammals in having their skin protected by large horny scales. When threatened, they can curl up into a ball, the sharp plate edges providing additional defence. Large, powerful front claws are used to excavate ant hills and termite mounds in search of food, captured by sticky saliva on their long, probing tongue.



SUNDA PANGOLIN
Manis javanica
Females of this semi-arboreal Asian species usually have one offspring, which is carried on the tail when a few days old.

AFRICAN TREE PANGOLIN
Manis tricuspis
This arboreal pangolin from equatorial Africa has pale fur and distinctive three-pointed scales, although the points can become worn with age.

LONG-TAILED PANGOLIN
Manis tetradactyla
This small pangolin from W. Africa lives high in the forest canopy. It has a prehensile tail two-thirds of its total body length.

INDIAN PANGOLIN
Manis crassicaudata
Its overlapping scales and ability to emit a noxious defensive fluid can protect this pangolin even from the attentions of tigers.

GROUND PANGOLIN
Manis temminckii
The only pangolin in southern and eastern Africa, this species is very secretive. It is nocturnal and walks on four feet, or two if foraging for food.

CARNIVORES

Predominantly meat-eaters, carnivores have a body that is adapted for hunting and their teeth are specialized for grasping and killing prey.

The first known carnivore fossil dates to 55 million years ago. They were small, tree-dwelling, rather cat-like mammals, but their descendants, which include some of the largest predators on earth, display a range of forms and lifestyles. The order Carnivora ranges in size from the least weasel, 26 cm (10 in) long, to the southern elephant seal, which measures up to 5 m (16 ft) from nose to tail. The order includes the world's fastest land animal, the cheetah, and the famously idle giant panda. Carnivores are naturally present on every continent except Australia, where they have been introduced by man. They are not restricted to dry land – the 34 species of seal, sea lion, and walrus are more at home in the oceans.

CHARACTERISTICS

With such diversity, it can be difficult to ascertain what the animals of this order have in common. The most important shared characteristic of the group is their teeth. All members of Carnivora have four long canine teeth and a distinctive set of cheek teeth known as carnassials, which are modified for cutting meat. The sharp edges of the carnassials work like a pair of scissor blades when the animal opens and shut its jaws.

Most carnivores eat at least some meat, but few are exclusively carnivorous. Several species, such as the foxes and raccoons, are omnivores, eating a wide range of plant and animal foods. One species, the giant panda, is almost completely herbivorous, with a diet consisting mainly of bamboo.

SOLITARY OR SOCIAL

Carnivores may lead solitary lives, like most weasels and bears, or be highly social, like wolves, lions, and meerkats. Animals in the latter category live in highly organized co-operative groups, sharing responsibility for hunting, rearing young, and protecting their territory. Seals and sea lions are generally colonial during the breeding season, when they are obliged to return to dry land to mate and give birth; some species gather in hundreds or even thousands on favoured beaches.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CARNIVORA
FAMILIES	16
SPECIES	288

DEBATE

PINNIPED OR CARNIVORE?

Taken at face value, it seems unlikely that the aquatic seals, sea lions, and walruses, known as pinnipeds from the Latin for "web-footed", could belong to the same group as weasels and wildcats. But the structure of their skull and teeth, and the information coded in their DNA tells a different story. Pinnipeds have limbs modified for swimming, but – unlike whales – they are not wholly aquatic and must return to land in order to breed. Fossil and molecular evidence suggests that seals, sea lions, and the walrus share a common bear- or weasel-like ancestor, which diverged from the other carnivores about 23 million years ago.

DOGS, FOXES, AND RELATIVES

The Canidae are medium-sized, long-legged mammals, most of which have a bushy tail and erect ears. They are swift, intelligent predators, though most also eat plant foods. The highly social grey wolf is the ancestor of the domestic dog, a species domesticated by humans over 14,000 years ago, and now hugely varied in size and form.

50–75 cm
20–30 in

ARCTIC FOX
Alopex lagopus
This sturdy fox lives in the world's northernmost regions. Its variable colour forms include snowy white.

short, pointed face

large ears

BLANFORD'S FOX
Vulpes cana
A strictly nocturnal species, this fox inhabits steppe country of the Arabian Peninsula and the Middle East. It feeds upon invertebrates and fruits.

45–60 cm
18–23½ in

yellowish white underside

38–80 cm
15–32 in

BENGAL FOX
Vulpes bengalensis
This agile, omnivorous fox inhabits open country in Nepal and India. Pairs remain together from year to year and rear several litters together.

CORSAC FOX
Vulpes corsac
A social, pack-dwelling animal of the Asian steppes, the Corsac fox is an opportunistic hunter of small animals. It also eats vegetable matter.

39–57 cm
15½–22½ in

48–52 cm
19–20½ in

KIT FOX
Vulpes macrotis
Found in the S.W. USA, the kit fox is an efficient digger. Families live in burrows with up to 20 entrances.

SWIFT FOX
Vulpes velox
This close relative of the kit fox occurs in the C. USA and has been reintroduced in Canada, where it became extinct in 1938.

47–55 cm
18½–22 in

33–41 cm
13–16 in

FENNEC FOX
Vulpes zerda
The distinctive ears of this tiny, nocturnal N. African fox serve a dual purpose: providing keen hearing and shedding excess body heat.

pointed ears, black on top

35–55 cm
14–22 in

RÜPPELL'S FOX
Vulpes rueppellii
Ranging from N. Africa to Pakistan, this small, social fox survives desert conditions by eating a wide range of plants and animals.

59–90 cm
23–35 in

RED FOX
Vulpes vulpes
This highly adaptable hunter and scavenger is the world's most widespread carnivore, occurring throughout most of the northern hemisphere.

large, bushy tail, with a white tip

black lower limb

46–60 cm
18–23½ in

BAT-EARED FOX
Otocyon megalotis
Inhabiting open grassland and scrubby savanna in S. and E. Africa, this social fox feeds chiefly on termites and beetles.

PAMPAS FOX
Lycalopex gymnocercus
A native of temperate grassland in S. America, this solitary fox hunts a variety of small animals and occasionally sheep.

60–74 cm
23½–29 in

54–66 cm
21½–26 in

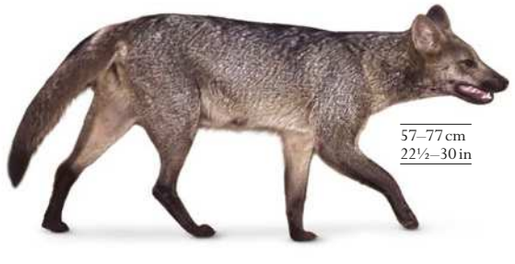
NORTHERN GREY FOX
Urocyon cinereoargenteus
This fox is a relatively common inhabitant of forested areas throughout the Americas, though it avoids areas where coyotes and bobcats live.

brown-black body fur

49–70 cm
19½–28 in

45–92 cm
18–36 in

CULPEO
Pseudalopex culpaeus
A large, solitary fox from the highlands of S. America, the culpeo hunts larger prey than most other fox species.



57–77 cm
22½–30 in

CRAB-EATING FOX
Cerdocyon thous
An adaptable omnivore from the grasslands and temperate and tropical forests of S. America, this species feeds on fruits, carrion, and small animals.

RACCOON DOG
Nyctereutes procyonoides
This unusual canid inhabits wetlands in E. Asia. It climbs well and is the only species of dog to hibernate.

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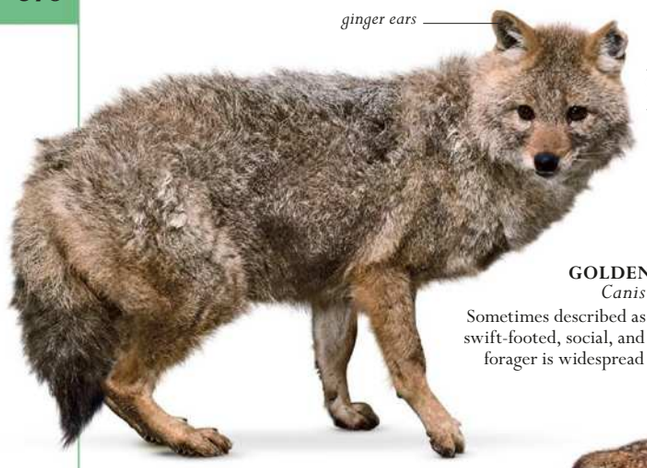
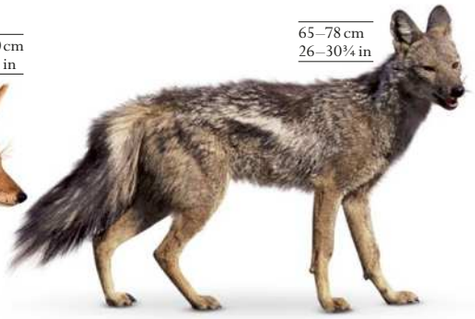


GOLDEN JACKAL
Canis aureus
Sometimes described as the archetypal canid,this swift-footed, social, and opportunistic hunter and forager is widespread across Africa and Asia.

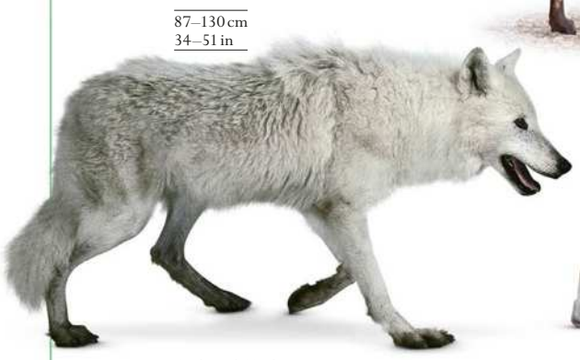
BLACK-BACKED JACKAL
Lupulella mesomelas
The largest of the African jackals, this adaptable, omnivorous canid lives in family groups. It is active day and night.



SIDE-STRIPED JACKAL
Lupulella adusta
A widespread African jackal, this species is a nocturnal scavenger and hunter. It is often persecuted by farmers.

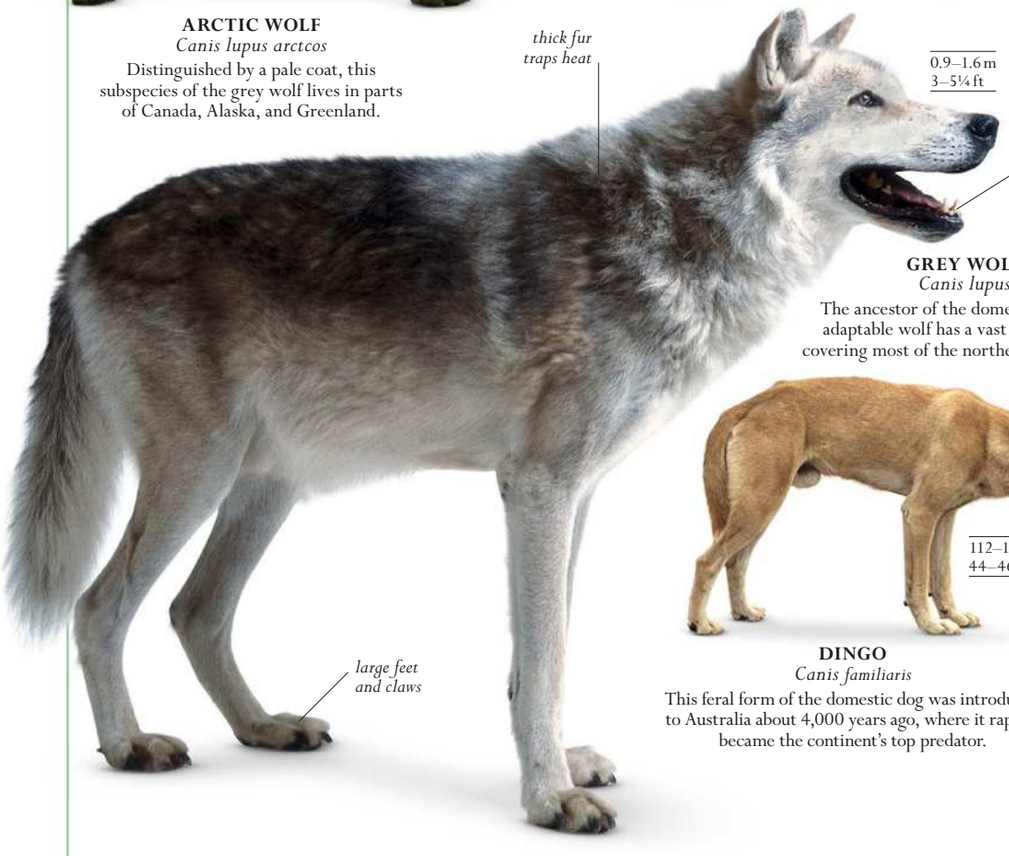
COYOTE
Canis latrans
Native to N. and C. America, this widespread and common species dwells in packs and occasionally mates with the grey wolf.

ETHIOPIAN WOLF
Canis simensis
Currently listed as the world's rarest canid, wild packs of this threatened wolf survive only in the remote highlands of Ethiopia.

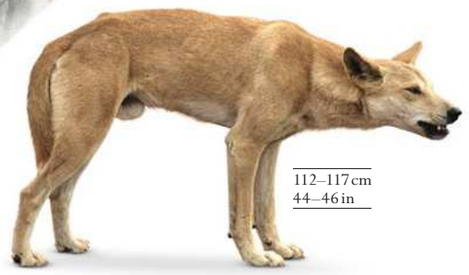


RED WOLF
Canis lupus rufus
This highly endangered subspecies from the S.E. USA survives on special reserves, thanks to captive breeding in the 1980s.

ARCTIC WOLF
Canis lupus arctcos
Distinguished by a pale coat, this subspecies of the grey wolf lives in parts of Canada, Alaska, and Greenland.



GREY WOLF
Canis lupus
The ancestor of the domestic dog, this adaptable wolf has a vast distribution, covering most of the northern hemisphere.



DINGO
Canis familiaris
This feral form of the domestic dog was introduced to Australia about 4,000 years ago, where it rapidly became the continent's top predator.

GOLDEN RETRIEVER
Canis familiaris
Bred in Scotland to retrieve game, this dog is loyal and intelligent, and makes an excellent pet. It loves being in water.

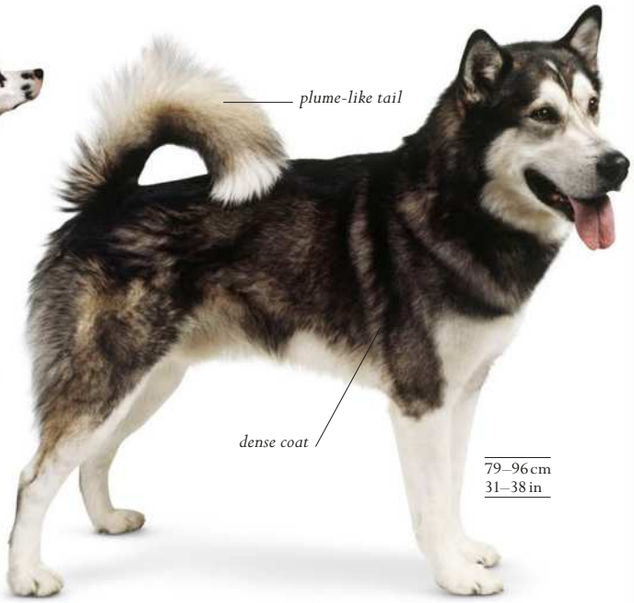
85–100 cm
2¾–3¼ ft

60 cm
23½ in

BASSET HOUND
Canis familiaris
This dog was bred as a tracking animal. Its short legs allow it to move easily through dense vegetation.

63–79 cm
25–31 in

DALMATIAN
Canis familiaris
Initially bred as guard dogs and hunting companions, dalmatians subsequently became coach dogs, escorting horsedrawn carriages. Today they are kept as pets.



79–96 cm
31–38 in

ALASKAN MALAMUTE
Canis familiaris
Bred in Alaska as a sled dog, the malamute resembles the ancestral wolf, and may be among the earliest domestic breeds.

MANED WOLF
Chrysocyon brachyurus
An opportunistic omnivore, the maned wolf inhabits S. American savanna, where its long legs help it to see over tall grasses.

95–115 cm
37–45 in

49 cm
19½ in

SMOOTH FOX TERRIER
Canis familiaris
An enthusiastic digger, small enough to enter fox burrows, this lively dog was bred to keep farms free of vermin.

67–85 cm
26–34 in

ROUGH COLLIE
Canis familiaris
Originally bred as a herding dog in the Scottish Highlands, this dog has an athletic build disguised by a thick coat.

20–30 cm
8–12 in

CHIHUAHUA
Canis familiaris
The smallest of domestic dog breeds, but bold-natured nonetheless, the chihuahua orginated in Mexico. Its coat can be of almost any colour.

0.9–1.4 m
35–55 in

DHOLE
Cuon alpinus
Known throughout its Asian range as a fierce predator, this wild canid lives and hunts in packs, targeting large mammals, such as deer and goats.

0.8–1.4 m
2½–4½ ft

AFRICAN WILD DOG
Lycaon pictus
This endangered canid lives in highly organized packs, hunting and rearing young co-operatively and supporting sick and injured relatives.

57–75 cm
22½–30 in

BUSH DOG
Speothos venaticus
This distinctive, short-legged species is a predator of the Amazon region. It hunts mainly rodents, working alone or in a pack.

POLAR BEAR
Ursus maritimus

This magnificent animal is as at home at sea as on land. It is the world's largest terrestrial predator, and its huge bulk can make it seem lumbering. In the water, however, it is transformed into a creature of effortless grace. Polar bears are true nomads and spend much of the year far from land, roaming the frozen expanse of the Arctic Ocean. In summer the melting ice forces them to retreat to land, where they sometimes come into contact with humans. Young polar bears are born in the middle of winter in a den dug by their mother. She scarcely wakes when they are born and nurses them in her sleep for three months, breaking down her own body reserves to create rich, fatty milk. Come the spring, the cubs have increased their birth weight dramatically, while the mother is close to starvation. She spends the next two years teaching them to swim, hunt seals, defend themselves, and build their own snow dens. Climate change is threatening the habitat and feeding habits of polar bears, which could result in this species' extinction.

unlike other bears, the polar bear has a slightly convex "Roman" nose

SIZE 1.8–2.8 m (6–9¼ ft)
HABITAT Arctic ice fields
DISTRIBUTION Arctic Ocean; polar regions of Russia, Alaska, Canada, Norway, and Greenland
DIET Mainly seals

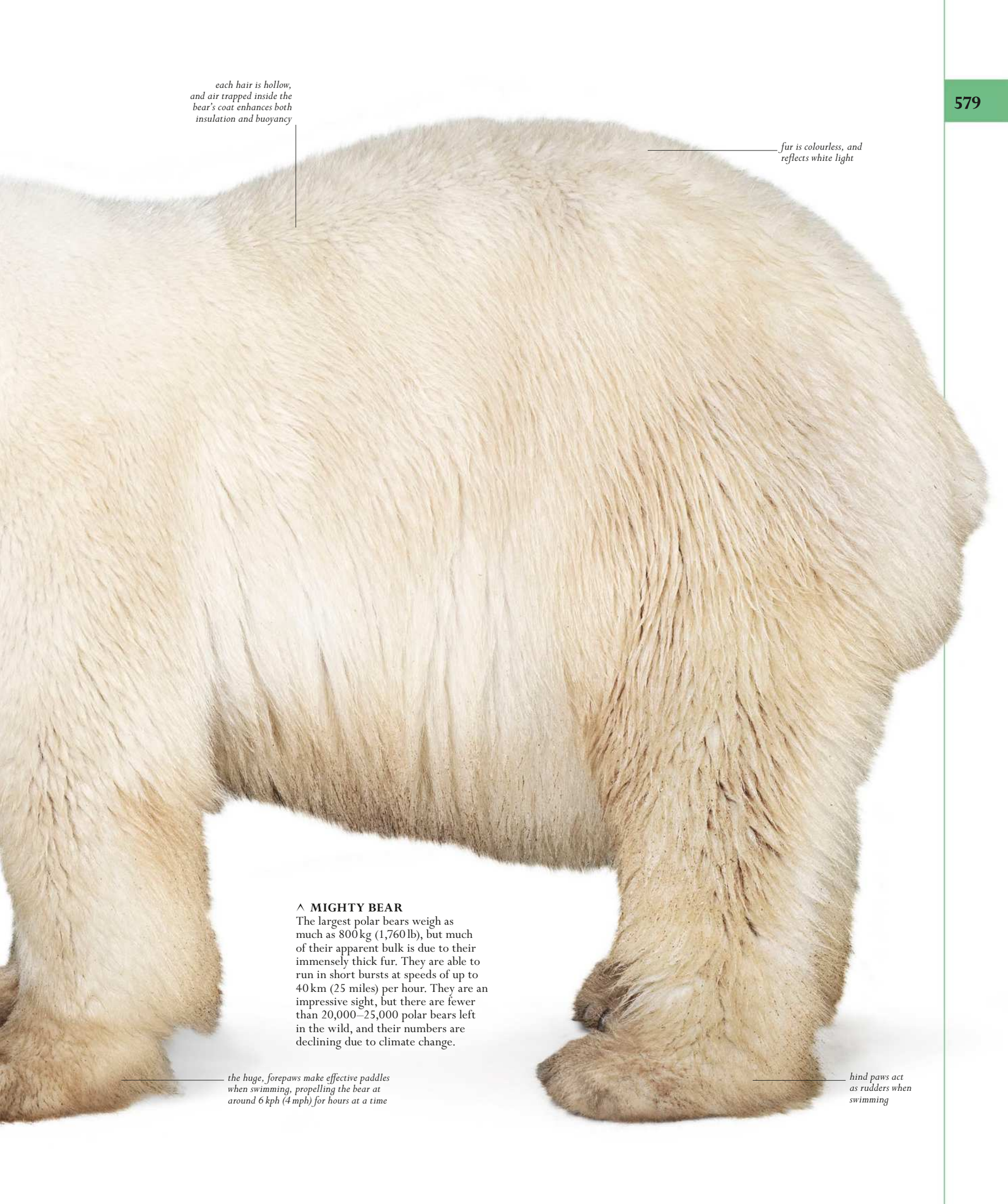
FURRY EARS >
The small ears are completely covered with fur to prevent frostbite. Polar bears have good hearing but rely mainly on their sense of smell to locate their prey.

< DARK EYE
The dark eyes and nose are the most conspicuous parts of the bear's body. Polar bears have good eyesight, comparable to that of humans.

^ CRUSHING BLOW
The front paws are the principle means of dispatching prey. Polar bears can smell seals below the ice and break into their lairs by rising up on their hind legs and crashing down with their forepaws. Then, they grab the seal and pull it out.

^ INSULATED PAWS
Polar bears have fur on the soles of their feet, which insulates them against the cold. The furry soles also help to prevent slipping when walking on ice.

^ STUBBY TAIL
The polar bear has little use for a long tail, so the appendage is reduced to a stub – all but hidden in the dense fur.


each hair is hollow, and air trapped inside the bear's coat enhances both insulation and buoyancy
fur is colourless, and reflects white light
the huge, forepaws make effective paddles when swimming, propelling the bear at around 6 kph (4 mph) for hours at a time
hind paws act as rudders when swimming

^ MIGHTY BEAR
The largest polar bears weigh as much as 800 kg (1,760 lb), but much of their apparent bulk is due to their immensely thick fur. They are able to run in short bursts at speeds of up to 40 km (25 miles) per hour. They are an impressive sight, but there are fewer than 20,000–25,000 polar bears left in the wild, and their numbers are declining due to climate change.

BEARS

The Ursidae are large, stocky-yet-agile animals native to Europe, Asia, and the Americas. Most bears are omnivorous, with plant material making up most of their diet. However, the polar bear is a specialized meat-eater and the giant panda is almost entirely herbivorous. Bears live alone except for mothers caring for their young.

BROWN BEAR
Ursus arctos

This bear's vast range, including Asia, N. Europe, and N. America, testifies to its dietary flexibility. It eats seasonal foods, including berries and spawning salmon.

1.2–1.8 m
4–6 ft

1.5–2.8 m
5–9¼ ft

white face with black eyes and ears

five claws grow to 10 cm (4 in)

GIANT PANDA
Ailuropoda melanoleuca

This endangered bear lives in central Chinese forests. Despite being a carnivore, it eats mostly bamboo; this lack of adequate nutrition results in a low-energy lifestyle.

EARED SEALS

Members of this family are distinguished from true seals by their small external ears and by their limbs, which can be used for moving on land – they are able to walk on their flippers, albeit in an ungainly manner. The Otariidae are excellent swimmers, but their dives are short and shallow compared with those of some true seals. They occur in most oceans except the North Atlantic.

STELLER'S SEA LION
Eumetopias jubatus

Also known as the northern sea lion, this North Pacific species is the largest of the eared seals. It eats mainly fish, but may take smaller seals.

thick neck

2–3.3 m
6½–11 ft

black flippers

ADULT

JUVENILE

dark brown or black pup

NEW ZEALAND SEA LION
Phocarctos hookeri

Found only in the waters around New Zealand, this rare species breeds only on a few offshore islands.

1.8–2.7 m
6–8¾ ft

1.3–2.5 m
4¼–8¼ ft

AUSTRALIAN SEA LION
Neophoca cinerea

This relatively rare species has breeding colonies restricted to Western and South Australia. Small groups stay together even outside the breeding season.

1.8–2.6 m
6–8½ ft

SOUTHERN SEA LION
Otaria bryonia

Thickset with a blunt face, this resident of S. America and the Falkland Islands in the South Atlantic occasionally hunts co-operatively and may enter rivers in search of fish.

dog-like muzzle with whiskers

streamlined body tapers from shoulder to tail

2–2.4 m
6½–7¾ ft

CALIFORNIA SEA LION
Zalophus californianus

Widely recognized as the "performing seal", this species is agile on land and in water, often leaping partly clear of the surface.

NORTHERN FUR SEAL
Callorhinus ursinus

Except when breeding, this species lives far offshore in the North Pacific. Males can be over five times heavier than females.

1.5–2.1 m
5–7 ft

AMERICAN BLACK BEAR
Ursus americanus
With about 850,000–950,000 individuals across varied habitats in N. America, this is the world's most common bear. Some have brown or blond fur.

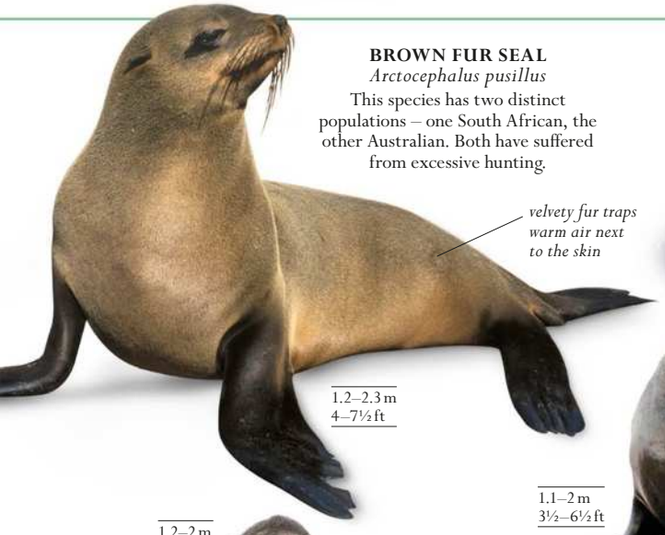
ASIATIC BLACK BEAR
Ursus thibetanus
A widespread forest-dweller, this bear is variable in appearance, habitat, and behaviour. In the tropics, only pregnant females hibernate.

POLAR BEAR
Ursus maritimus
One of the largest predators on land, the polar bear is equally at home in water. It spends most of its life on Arctic sea ice.

SLOTH BEAR
Melursus ursinus
This shaggy Indian bear can live in a range of habitats. It uses its huge claws to open termite mounds, sucking up the panicking insects.

SUN BEAR
Helarctos malayanus
This shy S.E. Asian forest bear eats insects, honey, fruits, and plant shoots. It is active by day, becoming nocturnal if disturbed.

SPECTACLED BEAR
Tremarctos ornatus
A vulnerable species of Andean cloud forests, this bear is an excellent climber. Its varied diet includes fruits, shoots, and meat.

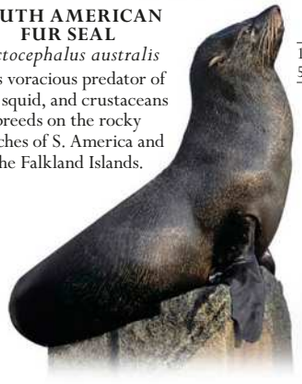


BROWN FUR SEAL
Arctocephalus pusillus
This species has two distinct populations – one South African, the other Australian. Both have suffered from excessive hunting.

GALAPAGOS FUR SEAL
Arctocephalus galapagoensis
The smallest of the eared seals, this species is also the least variable, with males only slightly larger than females.

GUADALUPE FUR SEAL
Arctocephalus townsendi
Distinguished by its long, tapering nose, this fur seal breeds on rocky beaches and caves accessible only from the sea.

ANTARCTIC FUR SEAL
Arctocephalus gazella
This species breeds on the scattered islands of the Southern Ocean. It is recovering from excessive hunting in the past.

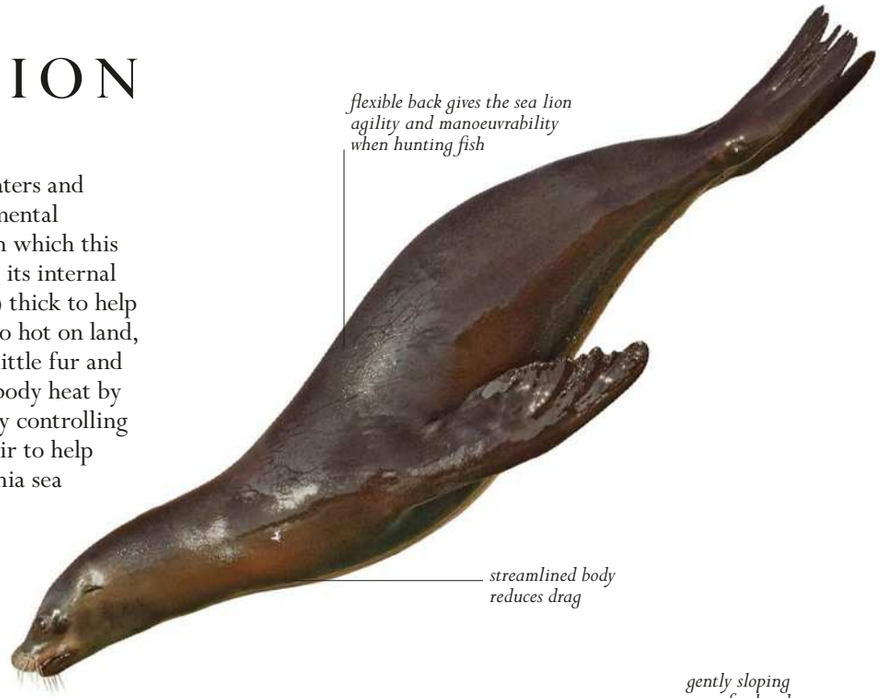


SOUTH AMERICAN FUR SEAL
Arctocephalus australis
This voracious predator of fish, squid, and crustaceans breeds on the rocky beaches of S. America and the Falkland Islands.

NEW ZEALAND FUR SEAL
Arctocephalus forsteri
This seal breeds on the rocky coasts of New Zealand and Australia. Now protected by law, it is no longer hunted and its numbers are increasing.

CALIFORNIA SEA LION
Zalophus californianus

The California sea lion lives in polar, temperate, and subtropical waters and on land, and therefore needs to cope with a wide range of environmental conditions. The waters in which it feeds are cold but the beaches on which this sea lion breeds can be hot, so it needs an efficient way of regulating its internal temperature. Its body has an insulating layer of blubber 2.5cm (1in) thick to help keep the sea lion warm when hunting in water and if it becomes too hot on land, it can cool down by returning to the sea. The flippers, which have little fur and lack blubber, have a heat exchange system that can retain or expel body heat by transferring it between arteries and veins at the flipper bases and by controlling blood flow to the skin. The fore flippers may also be waved in the air to help with cooling – a behaviour seen both in water and on land. California sea lions are hunted by sharks and orcas.



EAR >
Unlike seals, sea lions have small, pointed, external ear flaps that fold down and back against the head. They can hear well both on land and under water.

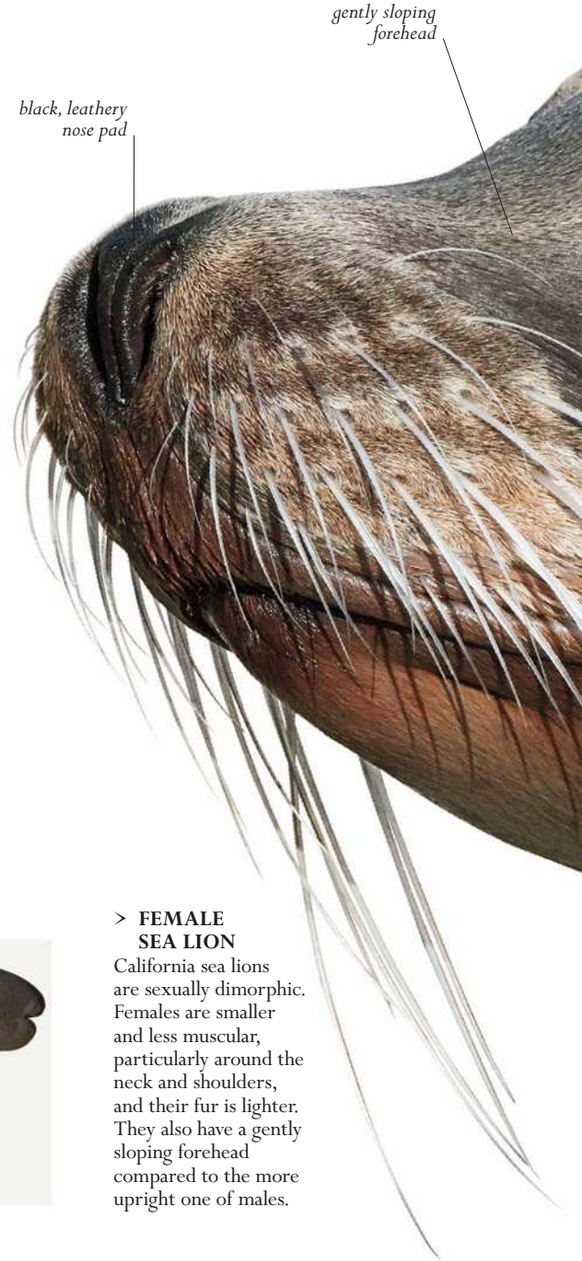
^ DIVING
Dives last for up to ten minutes during which the sea lion's heart rate falls to about 20 beats per minute.

^ MOUTH
The mouth contains 34 teeth. Initially white, they turn black with increasing age. The four large, recurved canines are used to grasp and hold on to prey.

^ NOSE
A sea lion's nostrils are only opened when inhaling or exhaling. The sensory whiskers help in working out the size and shape of objects when under water.

HIND FLIPPER >
In water, the hind flippers trail behind the body and are used for steering, but for moving on land they are rotated forwards and used with the front flippers.

v FORE FLIPPER
Swimming is powered by the long fore flippers, which enable the sea lion to achieve speeds of over 21 kph (13 mph).



> FEMALE SEA LION
California sea lions are sexually dimorphic. Females are smaller and less muscular, particularly around the neck and shoulders, and their fur is lighter. They also have a gently sloping forehead compared to the more upright one of males.

SIZE 2–2.4 m (6½–7¾ ft)
HABITAT Coasts and offshore waters
DISTRIBUTION Eastern North Pacific
DIET Mainly fish

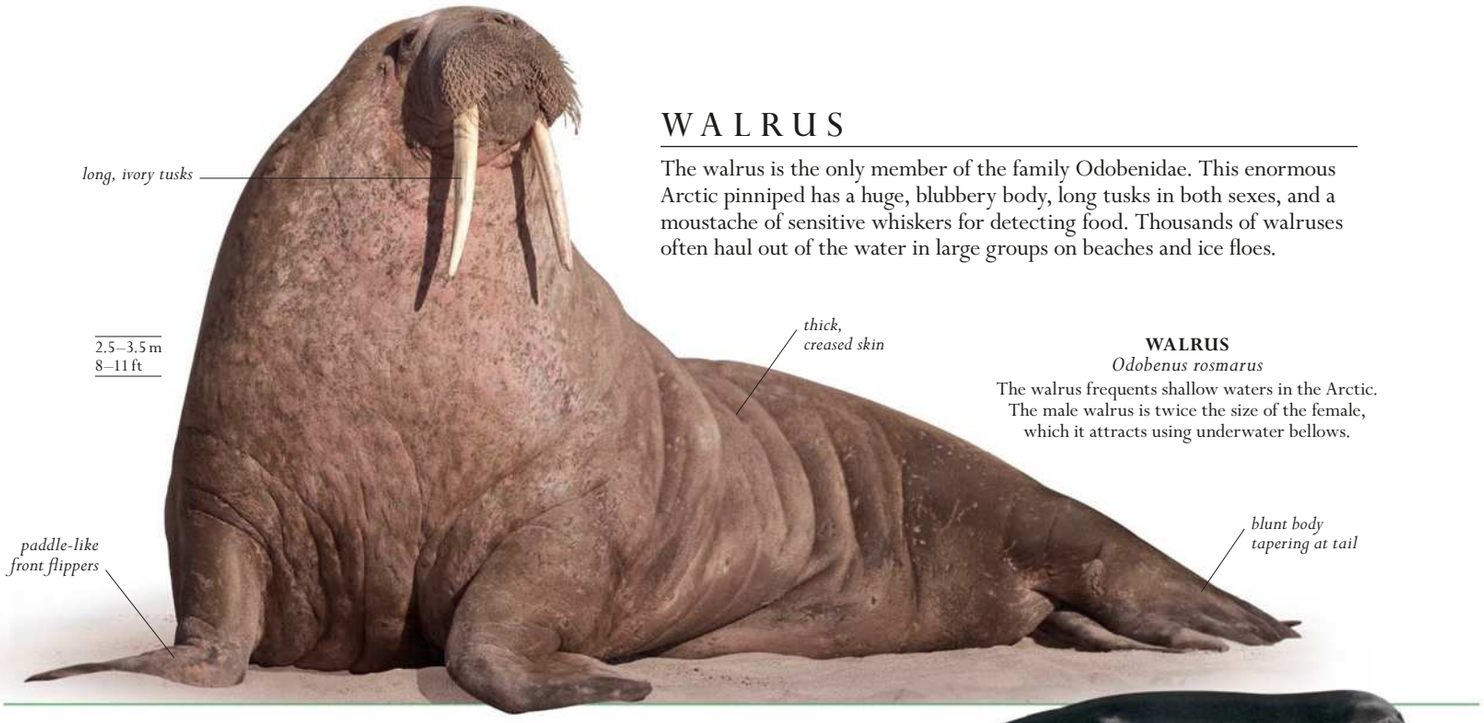
sea lions can see well on land and even better under water, helping them to locate prey

short, coarse fur

sensory whiskers (vibrissae) grow up to 20 cm (8 in) long

WALRUS

The walrus is the only member of the family Odobenidae. This enormous Arctic pinniped has a huge, blubbery body, long tusks in both sexes, and a moustache of sensitive whiskers for detecting food. Thousands of walruses often haul out of the water in large groups on beaches and ice floes.

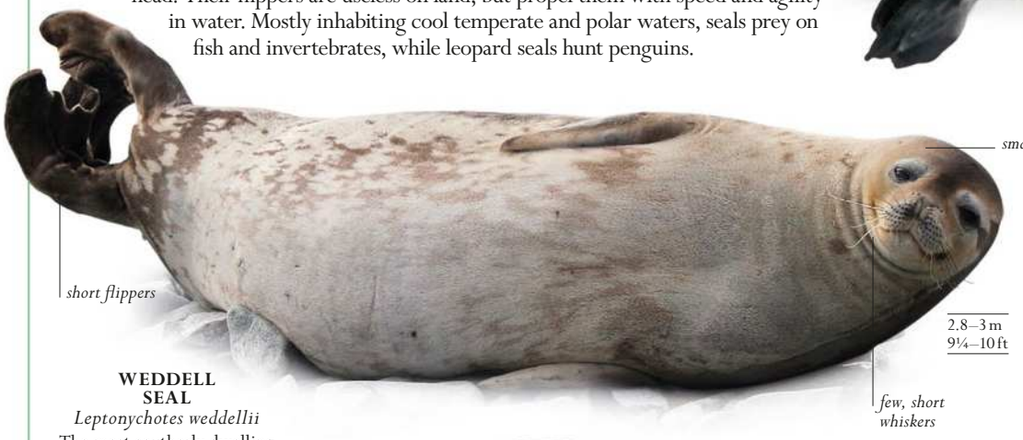


WALRUS
Odobenus rosmarus
The walrus frequents shallow waters in the Arctic. The male walrus is twice the size of the female, which it attracts using underwater bellows.

EARLESS SEALS

Also called true seals, the Phocidae are more adapted to life in water than their cousins, walruses and sea lions. In place of ear flaps, they have tiny holes on the sides of their head. Their flippers are useless on land, but propel them with speed and agility in water. Mostly inhabiting cool temperate and polar waters, seals prey on fish and invertebrates, while leopard seals hunt penguins.

ROSS SEAL
Ommatophoca rossii
This rare, fast-swimming seal spends most of its life hunting squid beneath Antarctic pack ice. Males are smaller than females.



WEDDELL SEAL
Leptonychotes weddellii
The most southerly dwelling wild mammal, this expert diver specializes in long, deep dives under Antarctic ice shelves. Females may be larger than males.

LEOPARD SEAL
Hydrurga leptonyx
This fearsome predator mostly ambushes smaller seals, fish, and penguins at the edge of Antarctic pack ice, though it also eats krill.

GREY SEAL
Halichoerus grypus
The grey seal lives in the North Atlantic, with large numbers breeding around Britain. Males are up to three times heavier than females.

BEARDED SEAL
Erignathus barbatus
This large, Arctic seal feeds on bottom-dwelling fish and invertebrates, which it locates partly by touch, using its long, stiff whiskers.

HAWAIIAN MONK SEAL
Monachus schauinslandi
Along with its Mediterranean relative, this is one of only two surviving, highly endangered and protected species of monk seals. Fewer than 1,000 of this species remain.

HARP SEAL
Pagophilus groenlandicus
This small seal migrates south in winter and north in summer in noisy groups, following the Arctic pack ice, on which it hauls out and rests.

2–2.4 m
6½–7¾ ft

CRABEATER SEAL
Lobodon carcinophaga
Despite its name, this agile Antarctic seal eats mainly krill, which it filters from the water, using specially modified teeth.

2–2.7 m
6½–8¾ ft

inflatable muzzle of male

HOODED SEAL
Cystophora cristata
This solitary, Arctic seal has an unusual, inflatable nose that droops over its mouth. The pups become independent at just five days old.

2.1–4 m
7–13 ft

♀

♂

NORTHERN ELEPHANT SEAL
Mirounga angustirostris
This is a large seal of the North Pacific. The male has a long, trunk-like nose. Like its southern relative, it was almost hunted to extinction, but is now recovering.

3–5 m
10–16 ft

SOUTHERN ELEPHANT SEAL
Mirounga leonina
The huge male of this Southern Ocean species has a trunk-like nose and is the largest carnivore, weighing up to 3,000 kg (6,610 lb).

1.5–1.8 m
5–6 ft

SPOTTED SEAL
Phoca largha
This small seal is mainly found on ice floes off the northern coasts of Siberia and Yukon, Canada. Adults form stable pairs in order to breed.

large eyes set back on head

spots, rings, and blotches on body

1.2–2 m
4–6½ ft

1.1–1.6 m
3½–5¼ ft

COMMON SEAL
Phoca vitulina
Also known as the harbour seal, this dainty seal is widespread along temperate coasts. It hauls on to sandy beaches and sheltered reefs.

RINGED SEAL
Pusa hispida
This small seal mainly inhabits Arctic ice shelves. Pups are born in lairs beneath the ice to protect them from predators.

1.2–1.5 m
4–5 ft

BAIKAL SEAL
Pusa sibirica
This small, freshwater seal is found in Lake Baikal, Siberia. In winter, it uses its teeth and claws to maintain breathing holes in the ice.

1.5 m
5 ft

CASPIAN SEAL
Pusa caspica
About 100,000 of this small species live in the Caspian Sea. Unusually, the male is believed to take only one mate, without fighting off other males.

SKUNKS AND RELATIVES

This small group of cat-sized mammals from the Americas is named for its most distinctive behaviour – that of squirting foul-smelling musk at an aggressor. The family name, Mephitidae, comes from the Latin word for "bad smell".

20–32 cm
8–12½ in

PALAWAN STINK BADGER
Mydaus marchei
This bumbling cousin of the American skunks is found only on the Philippine islands of Palawan and Calamian. It eats mainly invertebrates.

32–49 cm
12½–19½ in

HUMBOLDT'S HOG-NOSED SKUNK
Conepatus humboldtii
A native of S. Chile and Argentina, this small skunk detects underground invertebrate prey by scent and digs it up.

28–31 cm
11–12 in

EASTERN SPOTTED SKUNK
Spilogale putorius
A relatively small, weasel-like skunk from the E. USA, this species is more agile than other skunks and climbs well.

19–33 cm
7½–13 in

HOODED SKUNK
Mephitis macroura
This widespread C. American skunk occupies a range of habitats, feeding opportunistically on fruits, eggs, and small animals.

white stripe warns predators of foul secretions

long hairs on tail and back rise when animal is alarmed

17–40 cm
6½–16 in

STRIPED SKUNK
Mephitis mephitis
This nocturnal omnivore ranges from Canada to Mexico. It does not hibernate but can experience periods of torpor in winter.

RACCOONS AND RELATIVES

Raccoons, kinkajous, and olingos of the family Procyonidae are nimble New World carnivores. Most species are omnivorous and eat mainly plant material – especially fruits – and also insects, snails, small birds, and mammals. The raccoon is the largest of the group.

43–68 cm
17–27 in

SOUTH AMERICAN COATI
Nasua nasua
This species lives in loose female-dominated colonies. An agile climber, it mainly eats fruits, supplemented out of season with animal prey.

43–58 cm
17–23 in

WHITE-NOSED COATI
Nasua narica
This social C. American omnivore spends the day foraging at ground level. It climbs well, however, and often sleeps in trees.

tail has faint dark rings

RED PANDA

This tree-dwelling, herbivorous mammal is now placed in its own family, the Auluridae. Previously, zoologists had classified it with the bears but now it is thought to be most closely related to the group that includes skunks, raccoons, and weasels.

RED PANDA
Ailurus fulgens
This raccoon-like mammal inhabits temperate forest in the Himalayas. It eats bamboo, fruits, small animals, and birds' eggs.

51–78 cm
20–30¾ in

WEASELS AND RELATIVES

Members of the family Mustelidae occur throughout Eurasia, Africa, and the Americas. They are characterized by a sinuous body and short legs, though the badgers and wolverines are more robust. Most are active predators and good swimmers.

20–36 cm
8–14 in

EUROPEAN MINK
Mustela lutreola
A semi-aquatic predator, this species was once widespread in C. and W. Europe, but is now much less common than the introduced American mink.

30–43 cm
12–17 in

AMERICAN MINK
Neovison vison
A fierce and stealthy predator, this mink is also a skilled swimmer. It has been introduced worldwide by fur farmers.

tail has conspicuous black tip

30–40 cm
12–16 in

OLINGUITO
Bassaricyon neblina
Shy, nocturnal fruit-eaters, the olinguito is one of four species of olingo. It lives in the Andean cloud forests of Ecuador and Colombia.

41–76 cm
16–30 in

prehensile tail

KINKAJOU
Potos flavus
A nocturnal tree-dweller from C. and S. America, the kinkajou uses its long tongue to pluck fruits and collect honey from bee nests.

long fur is grizzled

44–62 cm
17½–24 in

NORTHERN RACCOON
Procyon lotor
This adaptable opportunist favours wooded and scrubby habitats across N. America, but often thrives in towns by scavenging human refuse.

black "bandit mask" around eyes

30–37 cm
12–14½ in

RINGTAIL
Bassariscus astutus
An agile omnivore from C. America, this species forages by night for fruits and small animal prey, pausing often to scent-mark territory.

20–46 cm
8–18 in

EUROPEAN POLECAT
Mustela putorius
This lively nocturnal species, found in forests and meadows of C. and W. Europe, is the ancestor of the domestic ferret.

19–34 cm
7½–13½ in

pointed muzzle

STOAT
Mustela erminea
This lithe and ferocious little predator is found throughout much of the northern hemisphere. Its most northerly populations turn white in winter.

40–50 cm
16–20 in

BLACK-FOOTED FERRET
Mustela nigripes
Extinct in the wild in the late 20th century, this slender burrowing ferret has been reintroduced to reserves in the mid-western USA.

11–26 cm
4¼–10 in

slender, elongated neck

LEAST WEASEL
Mustela nivalis
The smallest carnivore, yet a fierce and highly successful predator, this weasel specializes in hunting mice.

20–26 cm
8–10 in

LONG-TAILED WEASEL
Mustela frenata
A widespread species of the Americas, this weasel hunts mice and voles. Northern individuals turn white in winter.

»

55–70 cm
22–28 in

HOG BADGER
Arctonyx collaris
Native to S.E. Asia, this badger uses its elongated snout to root around for edible morsels on forest floors.

four white stripes from head to tail

42–72 cm
16½–28 in

AMERICAN BADGER
Taxidea taxus
This stout, burrowing animal inhabits grassland and woodland throughout central N. America. It eats a huge variety of plants and animals.

white stripe from nose, down the back to the rump

56–90 cm
22–35 in

EUROPEAN BADGER
Meles meles
This stocky badger inhabits wooded terrain across much of Europe and Asia. It lives communally in extensive burrow systems called setts.

74–96 cm
29–38 in

HONEY BADGER
Mellivora capensis
An exceptionally feisty animal, this species lives in W. and S. Asia, and Africa. It raids beehives for honey, but also eats termites, scorpions, and porcupines.

47–55 cm
18½–22 in

GREATER GRISON
Galictis vittata
This adaptable omnivorous weasel with badger-like markings is found in tropical forest and grassland in C. and S. America.

65–105 cm
26–41 in

WOLVERINE
Gulo gulo
This large mustelid is widespread in N. America and Eurasia. Its voracious feeding habits have earned it its other name, "glutton".

SABLE
Martes zibellina
This fierce predator from the forests of Siberia, China, and Japan is hunted in turn by humans for its luxuriantly soft, silky fur.

35–56 cm
14–22 in

flattened tapering tail

dense, dark brown coat

45–65 cm
18–26 in

FISHER
Martes pennanti
Found in dense N. American forests, this large marten rarely eats fish, and is one of the few predators to tackle porcupines.

45–58 cm
18–23 in

EUROPEAN PINE MARTEN
Martes martes
Present in forests throughout much of Europe, this lively hunter is seldom seen, as it is nocturnal and wary of humans.

40–54 cm
16–21½ in

BEECH MARTEN
Martes foina
Widespread in Eurasia, this marten emerges from a rock crevice or hollow log at dusk in search of small mammals, birds, and seasonal fruits.

AFRICAN ZORILLA
Ictonyx striatus
A striped polecat, this African species hunts a range of prey by night. It rests by day in hollow logs or burrows.

AFRICAN STRIPED WEASEL
Poecilogale albinucha
Found in C. and southern Africa, this species lives in self-dug burrows. It emerges at night to hunt for smaller animals, especially rodents, which it tracks by scent.

GIANT OTTER
Pteronura brasiliensis
This S. American predator needs 3 kg (2¼ lb) of fish a day to sustain itself. About 1,000–5,000 individuals of this endangered species remain.

AFRICAN CLAWLESS OTTER
Aonyx capensis
Found alongside water in forests and wetland throughout much of sub-Saharan Africa, this large otter eats mainly crabs, frogs, and fish.

ASIAN SMALL-CLAWED OTTER
Aonyx cinereus
The world's smallest otter, this species lives in wetlands in India and S.E. Asia. Its survival is threatened by habitat loss and pollution.

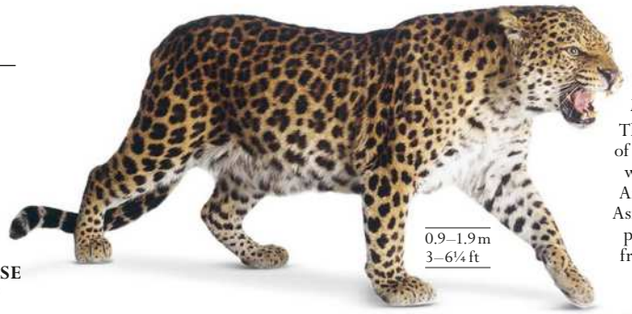
EURASIAN OTTER
Lutra lutra
Eurasian otters thrive in both river and coastal habitats, as long as they have access to fresh water for drinking and washing.

NORTH AMERICAN RIVER OTTER
Lontra canadensis
Widespread in N. America, this species inhabits well-vegetated rivers and lake shores. It eats mainly fish and crayfish, but also hunts small land animals.

SEA OTTER
Enhydra lutris
The sea otter hunts fish and shellfish in the cool North Pacific, relying on its incredibly dense fur to keep warm.

CATS

Members of the cat family, or Felidae, are among the most specialized of meat-eaters, and many species consume no vegetable material at all. As a group, cats are supremely athletic, having a supple, muscular body that is well adapted to running, climbing, leaping, and swimming. Their short jaws contain sharp teeth adapted for stabbing (canines) and slicing (carnassials). They have retractile claws.



0.9–1.9 m
3–6¼ ft

LEOPARD
Panthera pardus
This most adaptable of the big cats occurs widely throughout Africa and southern Asia. It often hides its prey in trees, away from other hunters.

67–107 cm
26–42 in

INDOCHINESE CLOUDED LEOPARD
Neofelis nebulosa
A large, nocturnal, S.E. Asian forest cat with cloud-shaped coat markings, this species is declining due to hunting and habitat loss.

BLACK LEOPARD
Panthera pardus
Melanistic black coloration is not uncommon among leopards. Also known as black panthers, they are found mainly in dense, moist forests in S.E. Asia.

0.9–1.9 m
3–6¼ ft

1.4–2.9 m
4½–9½ ft

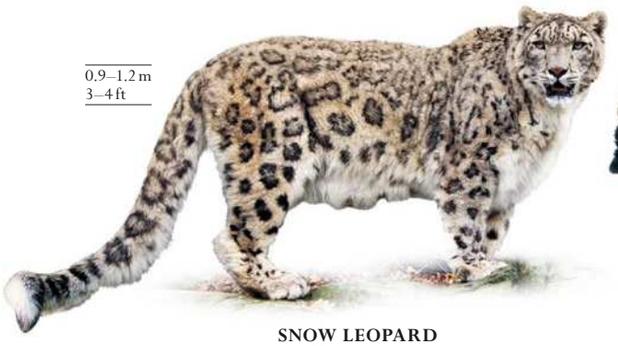
TIGER
Panthera tigris
The world's largest cat hunts using stealth and raw power to take prey as large as oxen. Fewer than 3,900 remain in the wild in Asia.

1.2–1.7 m
4–5½ ft

JAGUAR
Panthera onca
The America's only big cat, the jaguar is an excellent climber and swimmer. Its broad prey base includes deer, turtles, and fish.

1.6–2.5 m
5¼–8¼ ft

LION
Panthera leo
Africa's top predator lives in family groups known as prides. Females work together to bring down prey including zebra and antelope.



0.9–1.2 m
3–4 ft

SNOW LEOPARD
Uncia uncia
At home in the remote high mountains of C. Asia, the snow leopard lives alone and hunts wild sheep and goats, deer, and marmots.

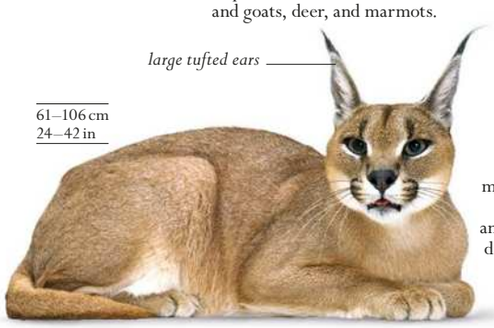
80–110 cm
32–43 in

EURASIAN LYNX
Lynx lynx
This large lynx is big enough to tackle small deer. One kill will feed an individual for about a week.

68–82 cm
27–32 in

IBERIAN LYNX
Lynx pardinus
Now being bred in captivity, this lynx is probably the world's most endangered cat, with fewer than 400 remaining wild in Spain.

large tufted ears



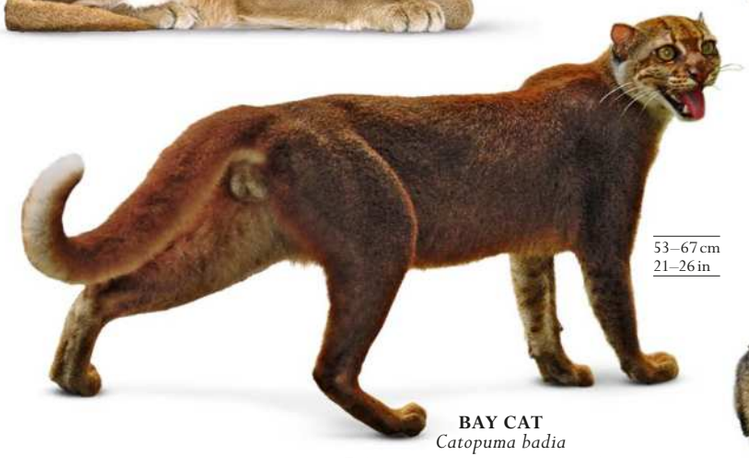
61–106 cm
24–42 in

CARACAL
Caracal sp.
Nocturnal hunters of medium-sized prey, such as hyraxes and small antelope, caracals occupy dry scrublands in Africa and S.W. Asia.

short tail

65–105 cm
26–41 in

BOBCAT
Lynx rufus
This adaptable stalk-and-pounce predator is named for its short "bob" tail. It occurs throughout N. America and hunts mainly rabbits.



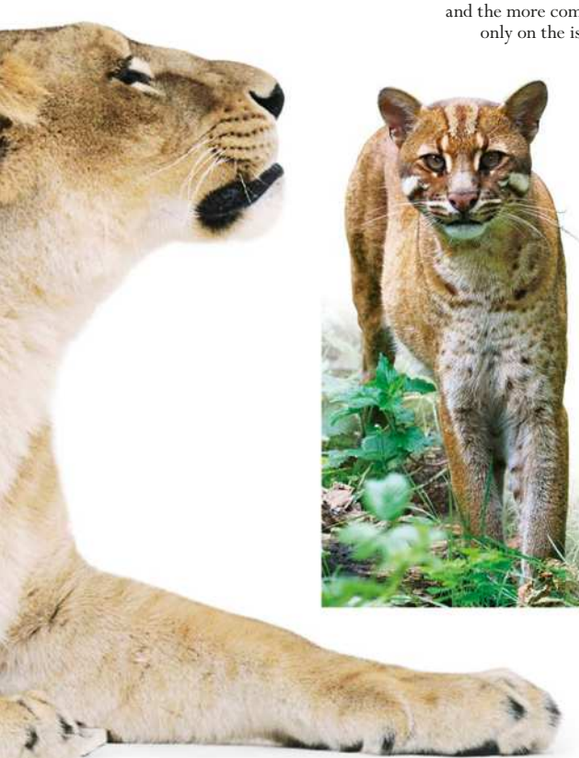
53–67 cm
21–26 in

BAY CAT
Catopuma badia
This rare cat has two colour morphs, grey and the more common red. It is found only on the island of Borneo.

76–107 cm
30–42 in

CANADIAN LYNX
Lynx canadensis
The Canadian lynx inhabits dense forests and tundra. Its numbers fluctuate with the availability of its preferred prey, the snowshoe hare.

small head with high-set eyes



ASIAN GOLDEN CAT
Catopuma temminckii
This large golden brown, occasionally spotty, cat inhabits forested parts of S.E. Asia. Pairs co-operate to hunt and rear young.

66–105 cm
26–41¼ in

CHEETAH
Acinonyx jubatus
The fastest animal on four legs, reaching 102 kph (63 mph), the cheetah uses speed to catch antelope on the African savanna.

1.2–1.5 m
4–5 ft

long tail aids balance

furry ears can swivel independently to scan surroundings for sounds of prey or danger

TIGER
Panthera tigris

The largest and most striking of the big cats, the tiger is a powerful predator with almost supernatural grace and agility. Its natural range extends from the tropical jungles of Indonesia to the snowy expanses of Siberia, where the largest individuals are found. A full-grown male may weigh anything up to 300 kg (660 lb), but despite this bulk it can leap up to 10 m (33 ft) in a single bound. Adult tigers live alone, except for females with cubs – mothers watch over their young for two years or more, while teaching them vital survival skills.

SIZE 1.4–2.9 m (4½–9½ ft)
HABITAT Forests, swamps, scrub thickets, savanna, and rocky landscapes
DISTRIBUTION India to China, Siberia, the Malay peninsula, and Sumatra
DIET Mainly hoofed animals, such as deer and pigs; may also catch smaller mammals and birds

sense of smell is surprisingly poor, although tigers do use scent marks to define their territory

long whiskers allow the tiger to feel its way through dense undergrowth in almost total darkness

ROUND PUPIL >
Unlike small cats, whose pupils contract to vertical slits, tiger pupils are always round. They expand to provide excellent night vision and contract to pinpricks in bright light.

WHITE EAR FLASH ∨
The prominent white spot on the back of each ear is thought to aid communication. Cubs following their mother will notice ear movements that may signal danger.

FORELIMBS >
The tiger has long legs and large feet, which allow it to run fast, leap large distances, and knock prey as large as oxen to the ground with a single, deadly swipe.

^ STAB AND SLICE
Four long canine teeth deliver the killing bite to a tiger's prey. Blade-edged cheek teeth called carnassials slice through the meat with ease.

^ PADDED PAW
Tigers have five toes on their front paws – four of which are weight-bearing and the fifth is the dew claw. The claws are withdrawn fully into the paw when not in use.

< KILLER IN STRIPES
A fiery orange coat marked with bold black stripes provides superb camouflage as the tiger moves through sun-dappled vegetation. The white tigers seen in zoos are usually bred in captivity and are extremely rare in the wild. Indeed, tigers have been hunted almost to extinction; globally, there are fewer than 3,900 left in the wild.

< TAIL END
The long tail is typically held curved just above the ground. The tiger uses it to aid balance when chasing prey or climbing.

35–50 cm
14–20 in

SIAMESE CAT
Felis catus
This elegant and sociable breed originated in Thailand. Siamese kittens are born cream and develop their dark extremities as they grow.

35–50 cm
14–20 in

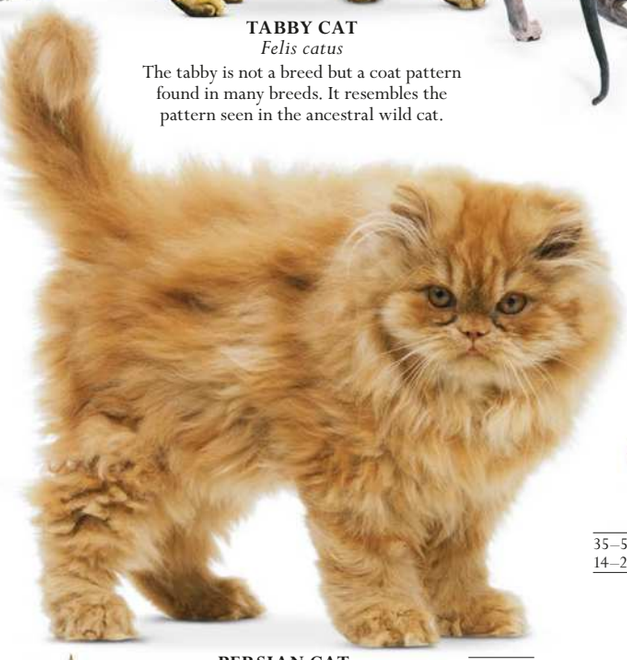
TABBY CAT
Felis catus
The tabby is not a breed but a coat pattern found in many breeds. It resembles the pattern seen in the ancestral wild cat.

35–50 cm
14–20 in

SPHYNX CAT
Felis catus
Hairless except for a peachy fuzz, sphynx cats were developed in Canada. As they feel the cold, they are most often kept as house cats.

35–50 cm
14–20 in

CORNISH REX
Felis catus
The Cornish rex has a coat made up only of down hairs. The curl of the fur is caused by a genetic mutation.



PERSIAN CAT
Felis catus
A long-established and popular breed, this domestic cat is characterized by long hairs and a short muzzle.

35–50 cm
14–20 in

35–50 cm
14–20 in

MANX CAT
Felis catus
Short-tailed cats appeared naturally on the Isle of Man over 300 years ago. The trait spread rapidly in the small island population.

47–66 cm
18½–26 in

EUROPEAN WILD CAT
Felis silvestris silvestris
This elusive but ferocious predator is declining due to persecution, habitat loss, and interbreeding with feral domestic cats.

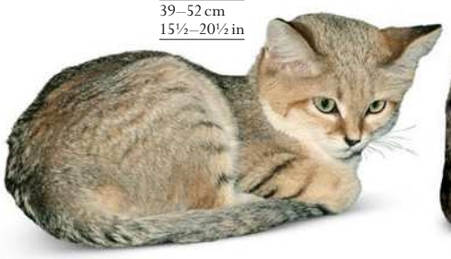
47–74 cm
18½–29 in

INDIAN DESERT CAT
Felis lybica ornata
This small felid, also known as the Asian steppe wild cat, can be distinguished from the two African subspecies by its brown-spotted, sandy-grey coat.

yellowish grey to reddish brown fur

61–85 cm
24–34 in

JUNGLE CAT
Felis chaus
A large and relatively common wild cat occuring from Egypt to Indonesia, the jungle cat prefers grassland and swampy habitats.



39–52 cm
15½–20½ in

SAND CAT
Felis margarita
A small desert specialist found in N. Africa, Arabia, and Kazakhstan, the sand cat hunts gerbils and other nocturnal rodents.

36–52 cm
14–20½ in

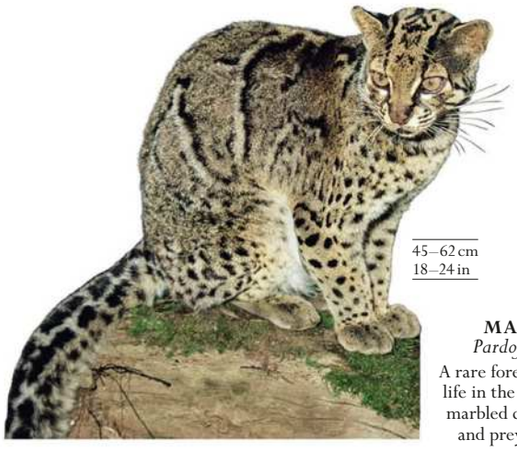
BLACK-FOOTED CAT
Felis nigripes
An opportunistic solitary hunter, the black-footed cat is threatened by persecution and habitat loss in its native southern Africa.

46–65 cm
18–26 in

PALLAS'S CAT
Otocolobus manul
This short-legged cat lives in the stony deserts of C. Asia. Its coat provides useful camouflage when stalking pikas, gerbils, and grouse.

59–92 cm
23–36 in

SERVAL
Leptailurus serval
Found in grassland habitats throughout much of Africa, this distinctive-looking cat is an agile predator of small mammals.

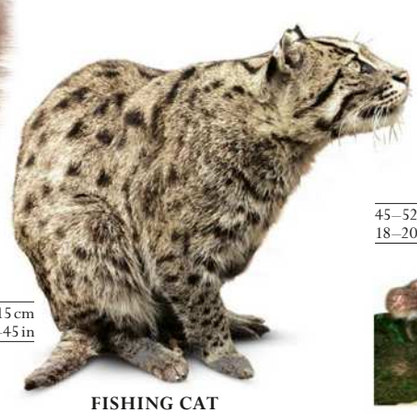


45–62 cm
18–24 in

MARBLED CAT
Pardofelis marmorata
A rare forest species adapted to life in the trees, the S.E. Asian marbled cat climbs brilliantly and preys mainly on birds.

35–48 cm
14–19 in

RUSTY-SPOTTED CAT
Prionailurus rubiginosus
This lively cat from India and Sri Lanka stalks most of its prey on the ground, but is also an excellent climber.



57–115 cm
22½–45 in

FISHING CAT
Prionailurus viverrinus
A large cat with a patchy distribution in S. and S.E. Asia, the endangered fishing cat also eats waterfowl and land animals.

45–52 cm
18–20½ in

FLAT-HEADED CAT
Prionailurus planiceps
This unusual water-loving cat from S.E. Asia hunts mainly fish and crustaceans, which it finds by dipping its head or groping with its paws.

»

» CATS

sandy coloured coat
round head with erect ears
large canine teeth for killing prey
long hind legs for exceptional sprinting and leaping power
0.9–1.6 m
2¾–5¼ ft

PUMA
Puma concolor
Also known as the cougar, panther, and mountain lion, the puma occupies rugged terrain across a vast range from Canada to Argentina.

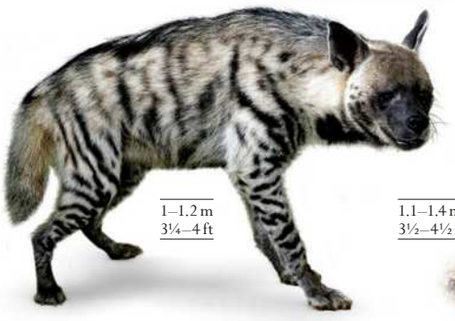
JAGUARUNDI
Herpailurus yagouaroundi
One of the largest and most widespread S. American cats, the jaguarundi hunts small mammals by day in diverse habitats.

HYENAS AND AARDWOLF

The small family of Hyaenidae contains three species of scavenging hyena and the aardwolf, which specializes in eating insects. Hyenas are characterized by a stocky, doglike body with short hind legs and powerful bone-crushing jaws. They are highly intelligent and live in family groups, called clans.

AARDWOLF
Proteles cristata
This dainty, weak-jawed cousin of the hyenas eats only insects. It lives in southern and E. Africa in the dry grassland favoured by termites.

SPOTTED HYENA
Crocuta crocuta
This efficient scavenger is also a proficient hunter of ungulates. It lives in unforested areas of sub-Saharan Africa.



STRIPED HYENA
Hyaena hyaena
The small striped hyena is found in open country from N. Africa to India. It eats a mixed diet of scavenged meat, small prey animals, and fruits.

BROWN HYENA
Hyaena brunnea
This social southern African scavenger survives desert conditions by foraging at night and supplementing its diet with watery fruits.

58–64 cm
23–25 in

ANDEAN CAT
Leopardus jacobita
This extremely rare species is restricted to remote uplands, where it is seldom seen by humans. It eats chinchilla-like rodents called viscachas.

spotted coat varies from grey to golden

43–88 cm
17–35 in

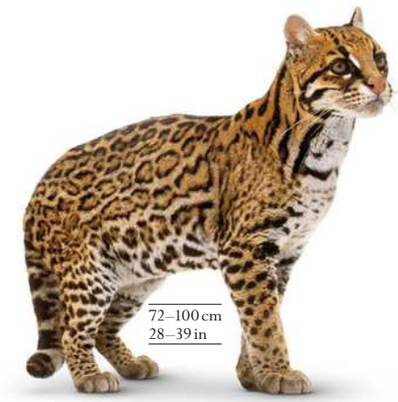
GEOFFROY'S CAT
Leopardus geoffroyi
An adaptable hunter of small mammals, fish, and birds, Geoffroy's cat stalks grasslands, forests, and wetlands from Bolivia to S. Argentina.

COLOCOLO
Leopardus colocolo
Highly adaptable, the mainly nocturnal colocolo is found in a wide variety of habitats in S. America, from forest to grassland and swamp.

42–79 cm
16½–31 in

38–56 cm
15–22 in

ONCILLA
Leopardus tigrinus
This spotted forest dweller is widespread from Costa Rica to Argentina, where it hunts rodents, opossums, and birds. It is solitary and nocturnal.



72–100 cm
28–39 in

OCELOT
Leopardus pardalis
Ocelots occupy forested parts of C. and S. America. They hunt nocturnally, targeting rodents and other prey on land and in water.

43–79 cm
17–31 in

large eyes adapted to nocturnal lifestyle

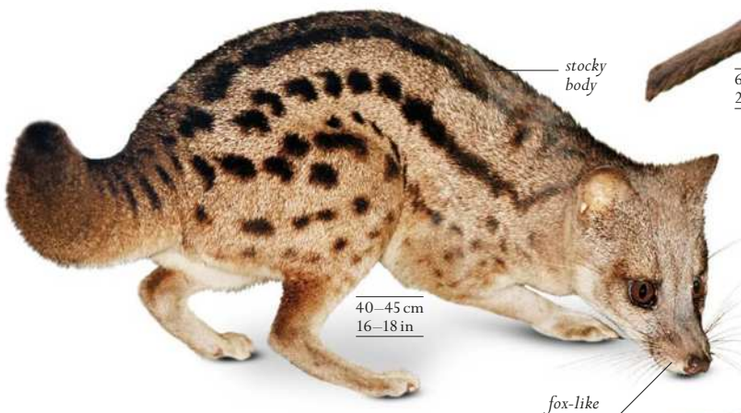
MARGAY
Leopardus wiedii
Seldom seen because of its rarity and preference for dense forest cover, the margay is found from Mexico to northern S. America.

lithe body adapted for climbing

strong claws are hidden within fleshy sheaths

MALAGASY CARNIVORES

The large island of Madagascar has been separate from other land masses for the last 88 million years, allowing its resident mammals to evolve independently. Its native carnivores are now classified in their own family, the Eupleridae. They are very varied in appearance, having diversified to fill the niches occupied elsewhere by predators such as cats, weasels, and mongooses.



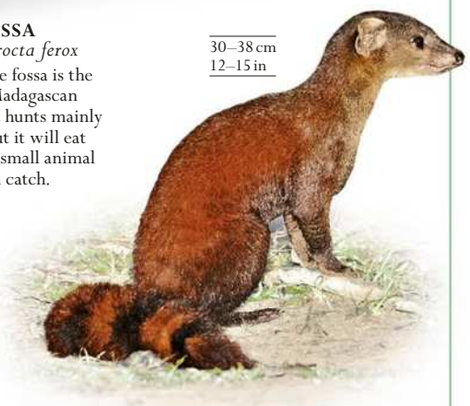
stocky body

40–45 cm
16–18 in

SPOTTED FANALOKA
Fossa fossana
A small civet-like animal, the spotted fanaloka inhabits Madagascar's wet forests. It hunts invertebrate prey on land and in water.

60–80 cm
23½–32 in

FOSSA
Cryptoprocta ferox
The cat-like fossa is the largest Madagascan carnivore. It hunts mainly lemurs, but it will eat almost any small animal it can catch.



30–38 cm
12–15 in

RING-TAILED VONTSIRA
Galidia elegans
The Madagascan equivalent of mongooses, vontsiras are active forest animals. They feed opportunistically on most plant and animal foods.

fox-like pointed muzzle

45–50 cm
18–20 in

FALANOUC
Eupleres goudotii
A ground-dwelling, nocturnal forest animal, the falanouc is an adept digger. It uses its large feet to unearth invertebrate prey.

v DEMOLITION EXPERT
This tough scavenger can reduce a carcass to nothing in minutes. It will attempt to bolt great chunks of meat before other scavengers arrive. Then, if time allows, it dismembers the remains and stashes them nearby. Often, all that is left of a herbivore, such as an antelope, is the green stomach contents.

crest of long hairs along the back lies flat when the animal is relaxed
shorter hind legs add to the front-heavy, skulking appearance

SIZE 1–1.2 m (3¼–4 ft)
HABITAT Open country, savanna grassland, and scrub to semi-desert
DISTRIBUTION North and East Africa, Middle East to East India
DIET Mainly carrion

STRIPED HYENA
Hyaena hyaena

Maligned in folklore as skulking, cowardly scavengers, most hyenas are also adept hunters in their own right. The striped hyena is less bold and sociable than its spotted cousin, and, in Africa at least, individuals tend to live a solitary life except when breeding. Elsewhere, such as in Israel and India, striped hyenas more often live in family groups, which are dominated by a single adult female. Carrion forms the bulk of the striped hyena's diet, but it is also partial to fruits, especially melons, which provide valuable water. Striped hyenas are unpopular with farmers, who fear attacks on livestock and damage to crops, but these animals increasingly need conservation, with perhaps fewer than 10,000 remaining in the wild.

muscular shoulders and neck allow the hyena to carry or drag its own bodyweight in carrion

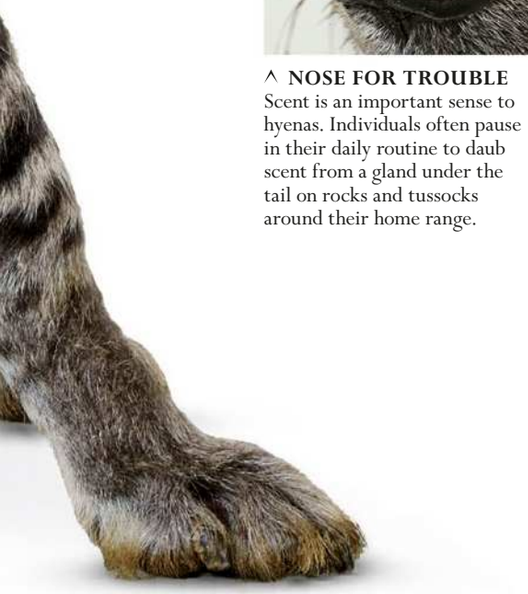
large ears follow sound from any direction

∨ THROAT
The black throat patch probably contributes to the animal's camouflage. The thicker hair in this area may provide some protection against serious injury when fighting.

∧ NOSE FOR TROUBLE
Scent is an important sense to hyenas. Individuals often pause in their daily routine to daub scent from a gland under the tail on rocks and tussocks around their home range.

∧ MOUTH AND TEETH
The hyena's stout jaws are operated by immensely powerful muscles. The large cheek teeth (molars and premolars) are easily capable of crushing bones.

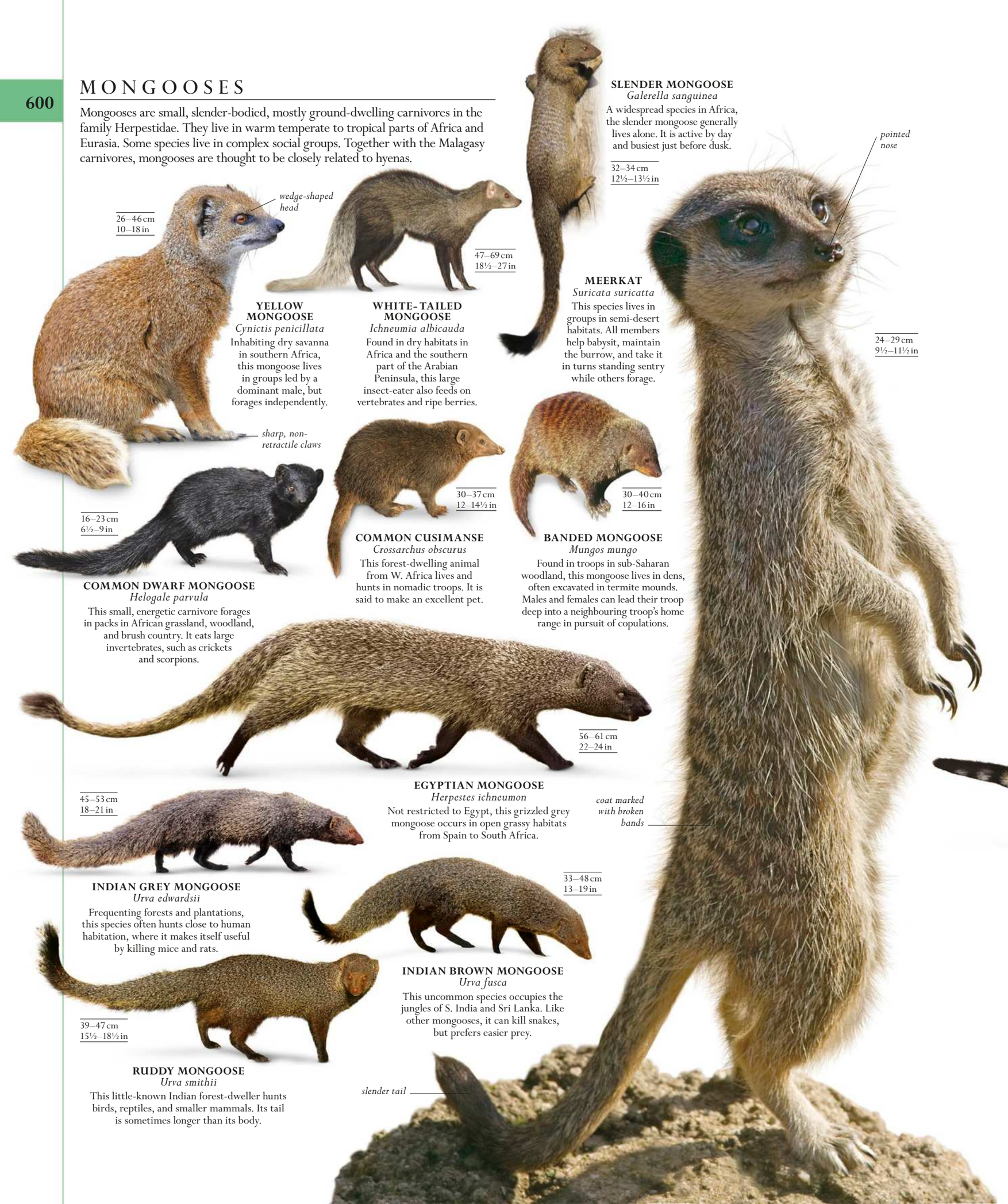
< FUR
The striped hyena is smaller than the spotted or brown hyena, and is distinguished by black stripes on its legs and flanks. The pattern aids camouflage in its dusty habitat.



< ∧ LEGS AND FEET
The front legs are longer than the back and terminate in compact paws with four digits on each. The claws are dog-like and are short, blunt, and nonretractile.

MONGOOSES

Mongooses are small, slender-bodied, mostly ground-dwelling carnivores in the family Herpestidae. They live in warm temperate to tropical parts of Africa and Eurasia. Some species live in complex social groups. Together with the Malagasy carnivores, mongooses are thought to be closely related to hyenas.



YELLOW MONGOOSE
Cynictis penicillata
Inhabiting dry savanna in southern Africa, this mongoose lives in groups led by a dominant male, but forages independently.

WHITE-TAILED MONGOOSE
Ichneumia albicauda
Found in dry habitats in Africa and the southern part of the Arabian Peninsula, this large insect-eater also feeds on vertebrates and ripe berries.

SLENDER MONGOOSE
Galerella sanguinea
A widespread species in Africa, the slender mongoose generally lives alone. It is active by day and busiest just before dusk.

MEERKAT
Suricata suricatta
This species lives in groups in semi-desert habitats. All members help babysit, maintain the burrow, and take it in turns standing sentry while others forage.

COMMON DWARF MONGOOSE
Helogale parvula
This small, energetic carnivore forages in packs in African grassland, woodland, and brush country. It eats large invertebrates, such as crickets and scorpions.

COMMON CUSIMANSE
Crossarchus obscurus
This forest-dwelling animal from W. Africa lives and hunts in nomadic troops. It is said to make an excellent pet.

BANDED MONGOOSE
Mungos mungo
Found in troops in sub-Saharan woodland, this mongoose lives in dens, often excavated in termite mounds. Males and females can lead their troop deep into a neighbouring troop's home range in pursuit of copulations.

EGYPTIAN MONGOOSE
Herpestes ichneumon
Not restricted to Egypt, this grizzled grey mongoose occurs in open grassy habitats from Spain to South Africa.

INDIAN GREY MONGOOSE
Urva edwardsii
Frequenting forests and plantations, this species often hunts close to human habitation, where it makes itself useful by killing mice and rats.

INDIAN BROWN MONGOOSE
Urva fusca
This uncommon species occupies the jungles of S. India and Sri Lanka. Like other mongooses, it can kill snakes, but prefers easier prey.

RUDDY MONGOOSE
Urva smithii
This little-known Indian forest-dweller hunts birds, reptiles, and smaller mammals. Its tail is sometimes longer than its body.

AFRICAN PALM CIVET

The secretive and nocturnal African palm civet is the sole member of the Nandiniidae, which is thought to have split from civet and cat-like ancestors 44.5 million years ago.

42–71 cm
16½–28 in

AFRICAN PALM CIVET
Nandinia binotata
This is a very common but shy tree-dwelling species from C. Africa. Though an omnivore, it eats mostly fruits.

CIVETS, GENETS, AND LINSANGS

With most species possessing a boldly patterned coat, the civets and genets (family Viverridae) and the lingsangs (family Prionodontidae) resemble long-tailed cats, but are less specialized meat-eaters. When threatened, these shy and nocturnal animals squirt a jet of foul-smelling fluid from stink glands near the base of the tail.

61–97 cm
24–38 in

BINTURONG
Arctictis binturong
Possessing a prehensile tail, this S.E. Asian species moves methodically through the forest canopy in search of fruits and small animals.

67–84 cm
26–33 in

51–87 cm
20–34 in

42–71 cm
16½–28 in

ASIAN PALM CIVET
Paradoxurus hermaphroditus
With a natural range extending from Pakistan to Indonesia, this fruit-loving civet is considered a pest in palm and banana plantations.

AFRICAN CIVET
Civettictis civetta
An opportunistic animal, this large, ground-dwelling omnivore lives alone and marks its territory with a strong musky scent.

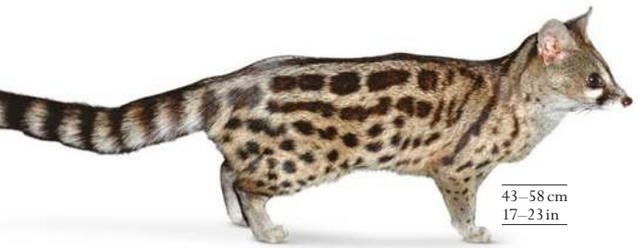
49–68 cm
19½–27 in

MASKED PALM CIVET
Paguma larvata
This agile, solitary, tree-dwelling native of Indochina eats fruits, insects, and small vertebrates.

46–52 cm
18–20½ in

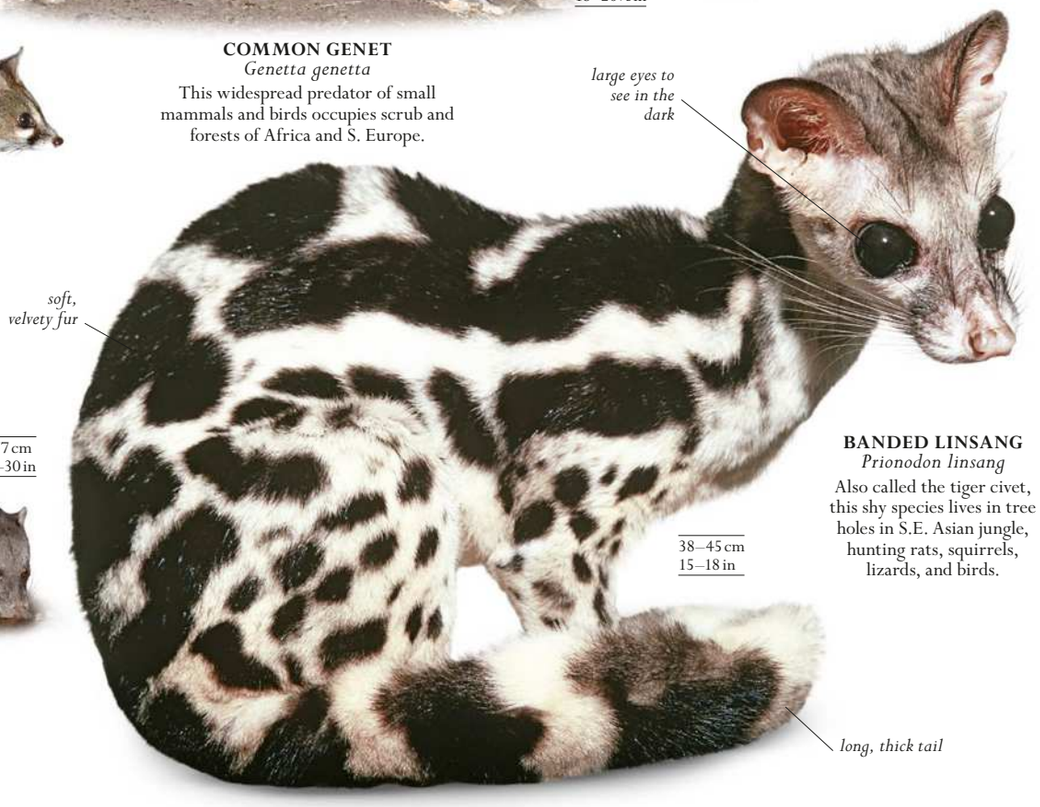
SMALL INDIAN CIVET
Viverricula indica
This small ground-dwelling civet inhabits forests, grasslands, and bamboo thickets from Pakistan to China and Indonesia.

COMMON GENET
Genetta genetta
This widespread predator of small mammals and birds occupies scrub and forests of Africa and S. Europe.



43–58 cm
17–23 in

CAPE GENET
Genetta tigrina
This genet is found in eastern South Africa and Lesotho. It eats mostly invertebrates, but will tackle prey as large as geese.



38–45 cm
15–18 in

BANDED LINSANG
Prionodon linsang
Also called the tiger civet, this shy species lives in tree holes in S.E. Asian jungle, hunting rats, squirrels, lizards, and birds.

54–77 cm
21½–30 in

MALAY CIVET
Viverra tangalunga
Restricted to the tropical forests of Malaysia, Indonesia, and the Philippines, this nocturnal forager mostly hunts for prey on the ground.

ODD-TOED UNGULATES

All members of the Perissodactyla are browsers and grazers of plants. They appear to have little in common, but are linked through a series of extinct intermediate forms.

Modern odd-toed ungulate families range from graceful horses to pig-like tapirs and massive rhinoceroses. Unlike the Artiodactyla, they have a relatively simple stomach, and rely on bacteria in the caecum, a pouch-like extension of the large intestine, and colon to digest plant cellulose.

In prehistoric times, odd-toed ungulates were among the most important herbivorous mammals, sometimes becoming the dominant herbivores in grassland and forest ecosystems. For a variety of reasons, including competition with even-toed ungulates, most of these species are now known only from the fossil record.

WEIGHT-BEARING TOES

Odd-toed ungulates rest their weight primarily on the third toe of each foot. Indeed, horses have lost the rest of their toes, and the single remaining digit is protected with a well-developed horny hoof. The other two families have retained more toes – three on all four feet in the case of rhinoceroses, and three on the hind legs and four on the front in the case of tapirs.

HORSE POWER

Once distributed across the world, apart from Antarctica and Australasia, extant species in this order are mainly native to Africa and Asia. Only some of the tapir species are found in the Americas, for although the horse family evolved in that region, it had died out by the end of the Pleistocene around 10,000 years ago. The Spanish conquistadors reintroduced the modern domestic horse to the Americas in the 15th century.

Horses have a long history of domestication, especially as transport and pack animals and to provide power for agriculture and forestry. The first equid to be domesticated appears to have been the donkey, some 5,000 years ago, with horses following 4,000 years ago. Today there are over 250 horse breeds worldwide.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PERISSODACTYLA
FAMILIES	3
SPECIES	18

The black rhinoceros is a browser and has a prehensile upper lip, which it uses to grasp twigs and leaves.

RHINOCEROSES

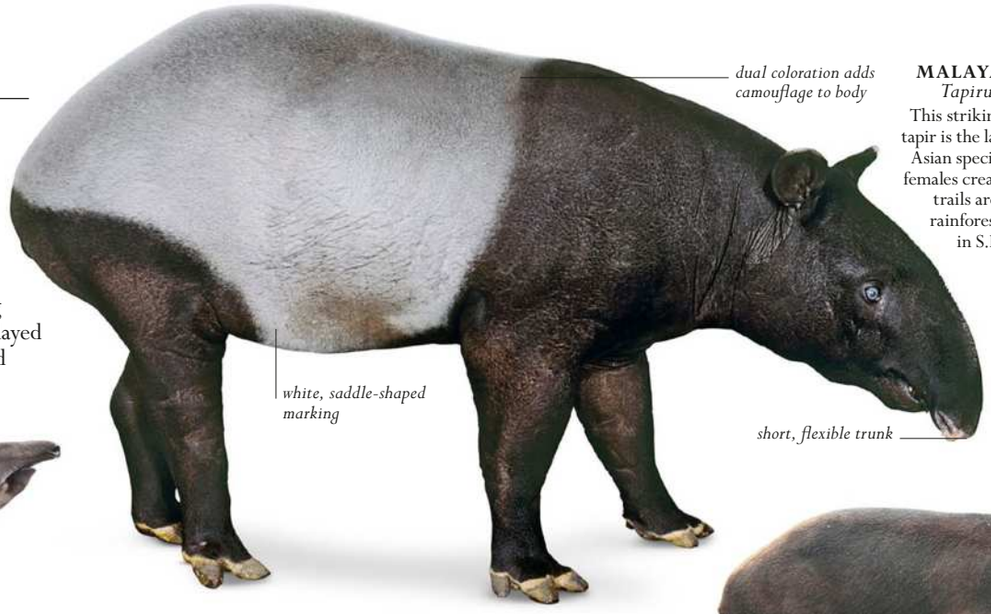
A huge, barrel-shaped body and a large head bearing one or two horns make the five species of the family Rhinocerotidae unmistakable. While their bulk, horns, and protective skin ensure they have few natural enemies, these mostly solitary animals are threatened by hunting and the destruction of their habitat. These herbivores can ferment food in their hindgut, which enables them to eat woody as well as leafy matter.

SUMATRAN RHINOCEROS
Dicerorhinus sumatrensis
This critically endangered species from S.E. Asian forests is the smallest rhinoceros. The smaller of its two horns is usually a mere stub.

BLACK RHINOCEROS
Diceros bicornis
Smaller but more aggressive than the white rhinoceros, this critically endangered animal of sub-Saharan Africa has a prehensile upper lip to draw twigs and leaves into its mouth.

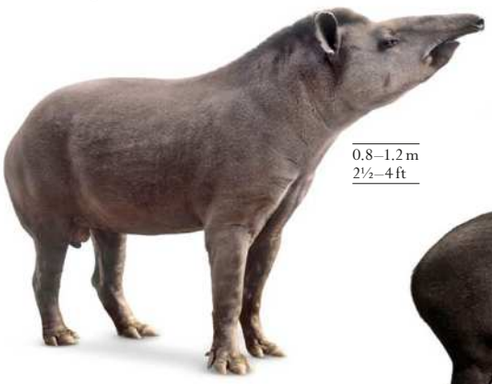
TAPIRS

Inhabiting tropical forests, the Tapiridae are found in Southeast Asia, and South and Central America. These large herbivores have a short prehensile trunk that can grasp foliage overhead and be used as a snorkel under water. Another distinctive feature is the protruding rump with a short tail. Young tapirs have a striped and spotted coat. Splayed hoofs, with four toes on the front feet and three on the rear, help tapirs walk on soft ground.



MALAYAN TAPIR
Tapirus indicus
This striking, two-toned tapir is the largest and only Asian species. Males and females create overlapping trails around their rainforest territory in S.E. Asia.

1–1.3 m
3¼–4¼ ft



0.8–1.2 m
2½–4 ft

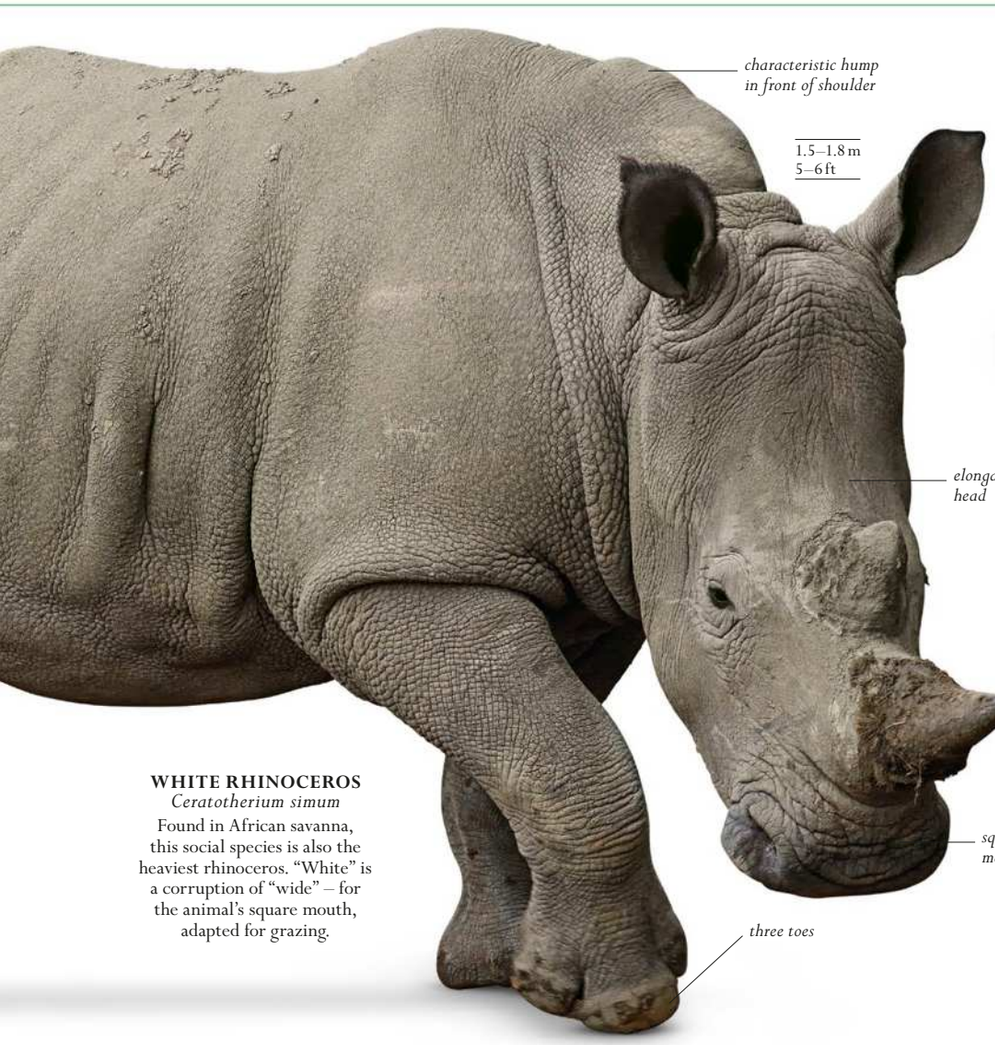
SOUTH AMERICAN TAPIR
Tapirus terrestris
Despite its size, this shy tapir is unobtrusive. It moves easily through jungle undergrowth. It is a favoured prey of crocodiles.

0.8–1.2 m
2½–4 ft

BAIRD'S TAPIR
Tapirus bairdii
The largest land mammal in S. America, this tapir favours waterside habitats in dense jungles and swamps for swimming and wallowing.

80–90 cm
32–35 in

MOUNTAIN TAPIR
Tapirus pinchaque
The smallest of all tapirs, this species inhabits montane cloud forest in the northern Andes. It has a thick, woolly coat and a white lower lip.



1.5–1.8 m
5–6 ft

WHITE RHINOCEROS
Ceratotherium simum
Found in African savanna, this social species is also the heaviest rhinoceros. "White" is a corruption of "wide" – for the animal's square mouth, adapted for grazing.

1.7–2 m
5½–6½ ft

INDIAN RHINOCEROS
Rhinoceros unicornis
Living in grasslands, forests, and wetlands of India and Nepal, this solitary, single-horned rhinoceros has thick folds of skin around its neck.

1.5–1.7 m
5–5½ ft

JAVAN RHINOCEROS
Rhinoceros sondaicus
Once widespread in S.E. Asia, this solitary, nocturnal browser is one of the world's rarest animals. Its small horn does not exceed 20 cm (8 in) in length.

»

WHITE RHINOCEROS
Ceratotherium simum

Despite its unnerving appearance, this giant of the African plains is a mild-tempered vegetarian. The huge horns are used almost entirely in self-defence or for protecting the young. Adult rhinoceroses usually live alone, although they sometimes form loose groups to share feeding areas. Males are territorial and mark their territory with pungent urine and droppings. They will compete for the right to mate with a certain female, but most disputes are solved with a bout of showing off, after which the weaker male backs down. This species has suffered a drastic decline in numbers and range as a result of habitat loss and hunting.

SIZE 1.5–1.8 m (5–6 ft)
HABITAT Savanna grassland
DISTRIBUTION C. and S. Africa
DIET Grass

∨ SHORT SIGHTED
Rhinoceroses are somewhat short sighted. Having eyes located on the sides of the head gives them a wide field of vision, but impairs their ability to see straight ahead.

∨ HAIRY EARS
The ears are the hairiest part of a rhinoceros's body. They provide excellent hearing, and swivel to detect sounds from any direction.

WIDE MOUTH >
The white rhinoceros is the largest animal to survive on an exclusive diet of grass. Its wide, straight mouth is shaped for maximum efficiency when cropping short grass.

< HORN OF HAIR
Rhinoceros horn is made of a protein called keratin. The same substance is found in hair and nails – in fact, the rhinoceros's horn is little more than a mass of compacted hair.

< RHINO HIDE
Despite the species' name, the tough, wrinkled skin of the white rhinoceros is grey, not white. Up to 2 cm (¾ in) thick, the skin is made up of layers of collagen, arranged in a criss-cross pattern.

front horn of a mature rhino can grow up to 1.5 m (5 ft) long

^ TELLING TAIL
The short tail hangs down when the rhinoceros is relaxed and curls up like that of a pig at times of excitement, such as when mating.

< THREE TOES
Rhinoceroses have three toes on each foot. Most of the weight is borne on the middle toe, with the smaller side toes aiding balance and grip.

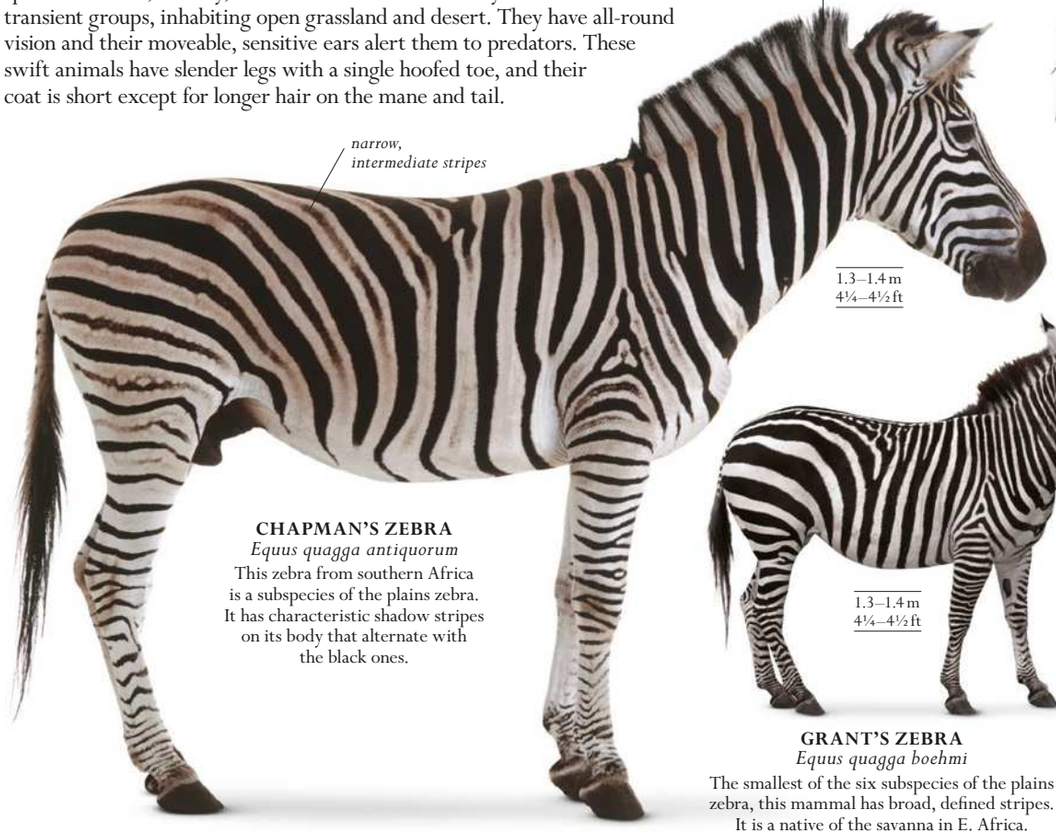
< UNDERSIDE OF FOOT
The unusual shape of a rhinoceros's foot makes the animal relatively easy to track. Some experienced trackers can even recognize individual animals from their footprint.

> GENTLE GIANT
White rhinoceroses suffer from an undeserved reputation for bad temper. In reality they are peace-loving, even timid, animals. Under normal circumstances they charge only when provoked or confused. The black rhinoceros is much more aggressive.

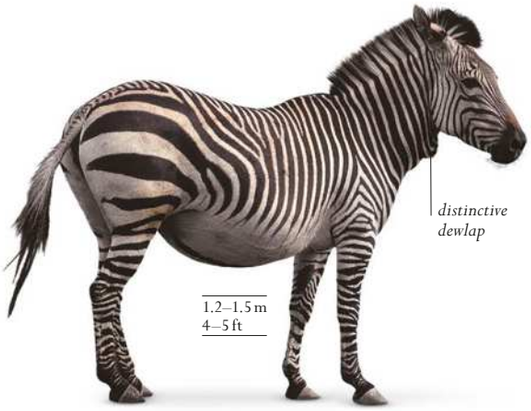
large nostrils and an
excellent sense of smell
make up for weak eyesight

HORSES AND RELATIVES

Although the Equidae are a large family in the fossil record, just nine species of horse, donkey, asses and zebra remain. They live in herds or transient groups, inhabiting open grassland and desert. They have all-round vision and their moveable, sensitive ears alert them to predators. These swift animals have slender legs with a single hoofed toe, and their coat is short except for longer hair on the mane and tail.



CHAPMAN'S ZEBRA
Equus quagga antiquorum
This zebra from southern Africa is a subspecies of the plains zebra. It has characteristic shadow stripes on its body that alternate with the black ones.



MOUNTAIN ZEBRA
Equus zebra
Found in S.W. Africa, this species lives in dry, rocky, mountainous habitats. It has broad stripes on the hindquarters that contrast with its narrow stripes elsewhere.

GRANT'S ZEBRA
Equus quagga boehmi
The smallest of the six subspecies of the plains zebra, this mammal has broad, defined stripes. It is a native of the savanna in E. Africa.

GREVY'S ZEBRA
Equus grevyi
The largest wild species in its family, this big-eared zebra from E. Africa has narrow, variable stripes on its body and a white belly.

KHUR
Equus hemionus khur
A fast runner from arid Asian grasslands, this subspecies is now found in the wild only in a sanctuary in Gujarat, India.

KULAN
Equus hemionus kulan
A little larger than most donkeys, this subspecies of the Asiatic wild ass has a black dorsal stripe, edged with white, and a short, upright mane.

PERSIAN ONAGER
Equus hemionus onager
Extinct in much of its former Asian range and now found only in parts of Iran, this subspecies has a brown dorsal stripe on its back.

KIANG
Equus kiang
The largest wild ass, the kiang inhabits the Tibetan Plateau. Its chestnut-coloured coat is the darkest of all Asian wild asses, and is woolly in winter.

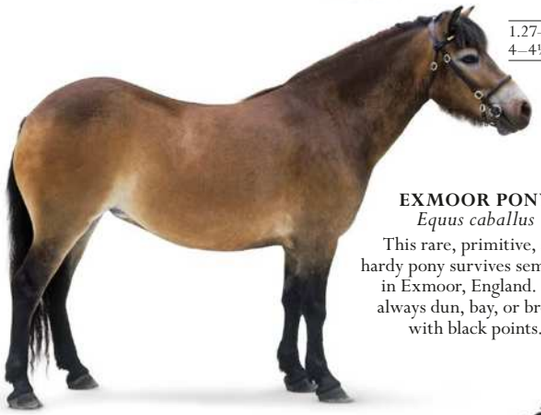
SOMALI WILD ASS
Equus africanus somalicus
The ancestor of the donkey, this wild ass from N.E. Africa has a short, grey coat, and striped, zebra-like legs.

DONKEY
Equus asinus
The domesticated form of the African wild ass, this subspecies has a worldwide distribution as a transport and pack animal.

PRZEWALSKI'S HORSE
Equus przewalskii
The last true wild horse, this species often bears faint leg stripes. It once survived only in captivity, but is now being reintroduced into the wild in Mongolia and China.

1.2–1.5 m
4–5 ft

pale muzzle



1.27–1.3 m
4–4¼ ft

EXMOOR PONY
Equus caballus
This rare, primitive, and hardy pony survives semi-wild in Exmoor, England. It is always dun, bay, or brown with black points.

SHIRE HORSE
Equus caballus
A large, powerful horse, bred in England from Dutch stock, this breed is still used in agriculture and forestry for pulling heavy loads.

1.7–1.9 m
5½–6¼ ft

ARAB HORSE
Equus caballus
A swift desert horse, the Arab has had a huge influence on the development of the modern racehorse.

1.5 m
5 ft

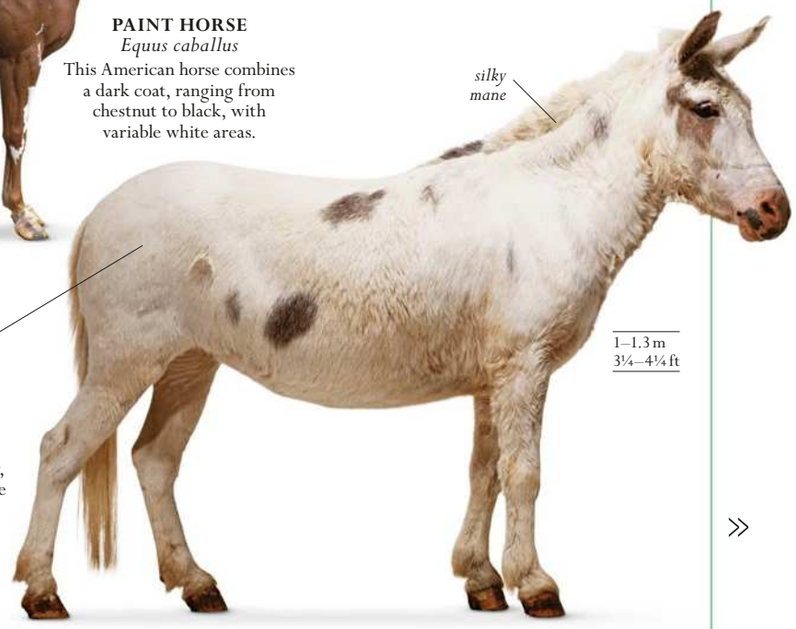
1.5–1.6 m
5–5¼ ft

PAINT HORSE
Equus caballus
This American horse combines a dark coat, ranging from chestnut to black, with variable white areas.

1.25–1.8 m
4–6 ft

MULE
Equus asinus x *E. caballus*
Built like a horse but with the paternal donkey's head and long ears, this generally sterile hybrid is a strong pack animal.

HINNY
Equus caballus x *E. asinus*
The offspring of a male horse and a female donkey, the hinny has a donkey-like body and the head, ears, and mane of a horse.



1–1.3 m
3¼–4¼ ft

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EVEN-TOED UNGULATES

One of two orders of hoofed mammals, the Artiodactyla stand on two or four toes. Most are herbivorous, and have a multi-chambered, fermenting stomach.

Even-toed ungulates are often described as cloven hoofed. This is because the tip of each toe has its own hoof – a hard, rubbery, sole surrounded by a thick nail. The hoof wears down through use, but grows continually. Only the camelids lack hoofs – although they walk on two toes, the hoof is reduced to a small nail.

CHEWING THE CUD

With long legs and their feet protected with hoofs, even-toed ungulates often range extensively across grassland and forested habitats in search of food. Most families are grazers of grass and herbs or browsers of shoots and leaves. Their digestive system is well adapted to a diet of tough vegetable matter: the stomach has three or four chambers and contains bacteria that digest the cellulose in plant cell walls, releasing nutrients inside. To help with this, partly digested food (cud) is regurgitated for further chewing, a process known as rumination. Artiodactyls also have large, broad cheek teeth to grind up their tough food, and long intestines. Pigs and peccaries are somewhat different: they do not ruminate, have more generalized teeth, and a more omnivorous diet. Sometimes the canine teeth are enlarged into tusks for defence, fighting, and rooting for food.

DOMESTICATION

Introduced into Australasia, members of this order are found on every continent except Antarctica. They vary greatly in shape and in size, with shoulder height ranging from 20 cm (8 in) in the mouse-deer to almost 4 m (13 ft) in the giraffe. Many species are hunted in the wild as food by humans, but others have been domesticated and are economically important – cattle, llamas, sheep, and pigs are used for meat, leather, wool, dairy products, and transport. Domestication has given rise to animal breeds with a distinctive appearance that matches their specific purpose.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	ARTIODACTYLA
FAMILIES	10
SPECIES	384

DEBATE

ONE SPECIES OR MORE?

During the last ten years, over 100 new bovid species have been described, often because taxonomists, scientists who classify things, have categorized different races (subspecies) of certain bovids as species in their own right. Genetic evidence is used to substantiate (or sometimes refute) these divisions. Giraffes, for example, were previously described as a single species containing a number of subspecies. However, recent DNA evidence supports their division into four species – the Masai (*G. tippelskirchi*), reticulated (*G. reticulata*), northern (*G. camelopardalis*; three subspecies), and southern giraffes (*G. giraffa* ; two subspecies).

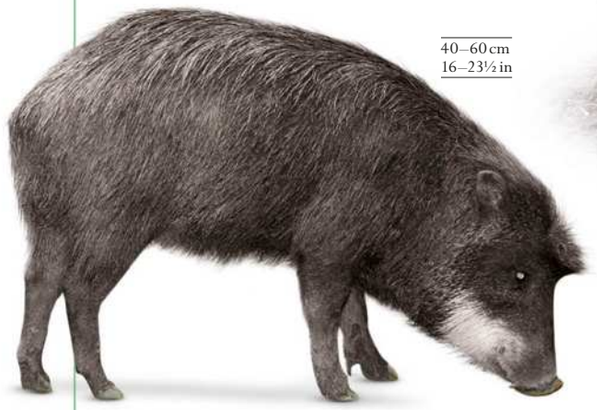
PECCARIES

Found in the Americas, the Tayassuidae share many features with pigs, such as small eyes and a snout that ends in a cartilaginous disc. But they have a more complex, chambered stomach, and short, straight tusks.

52–69 cm
20½–27 in

CHACOAN PECCARY
Catagonus wagneri

Found in the Chaco ecoregion of central S. America, this large peccary was first described from fossils, and was discovered to be a living species only in 1975.



40–60 cm
16–23½ in

WHITE-LIPPED PECCARY
Tayassu pecari

Living in large herds in C. and S. America, this species will group together and face-off a predator, but they are fast and will flee if necessary.

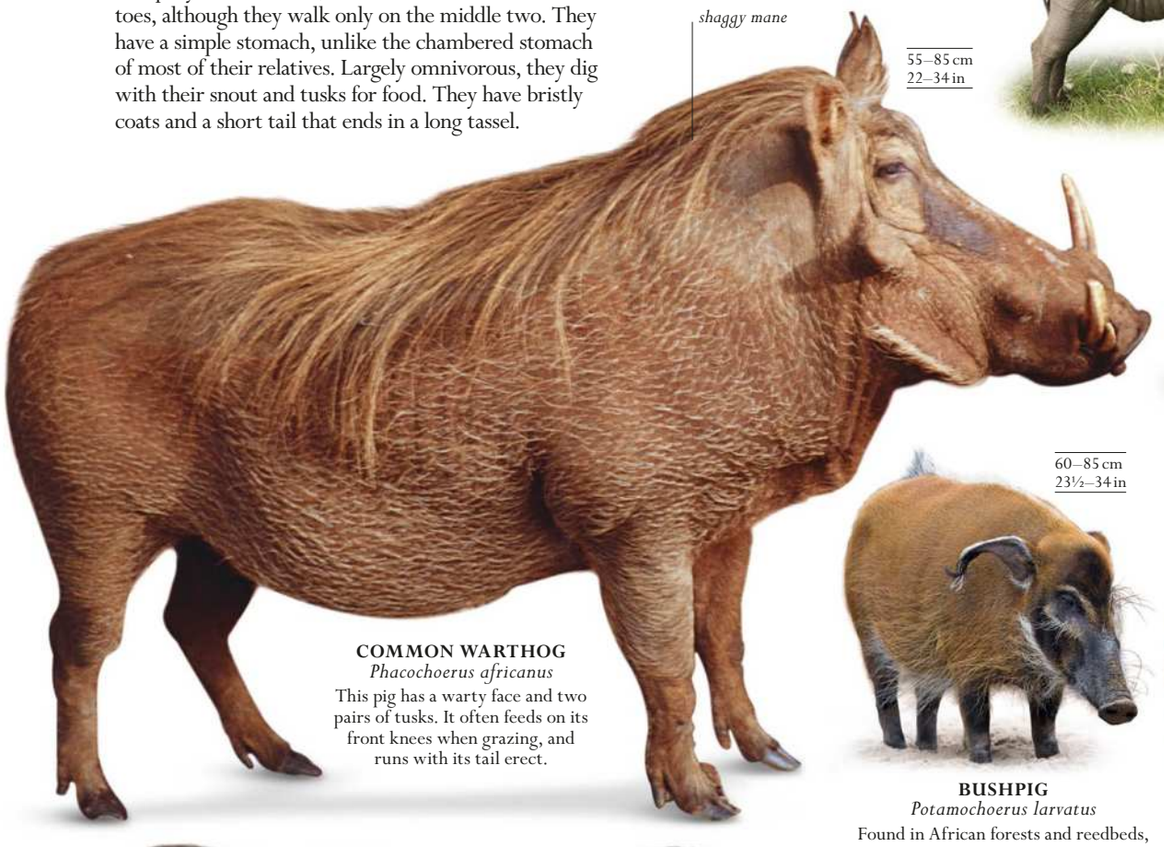
COLLARED PECCARY
Pecari tajacu

Widespread in the tropical and subtropical Americas, this diurnal pig is extremely social in nature. It is considered destructive in agricultural areas, as it often raids crops.

PIGS

Uniquely in their order, the Old World Suidae have four toes, although they walk only on the middle two. They have a simple stomach, unlike the chambered stomach of most of their relatives. Largely omnivorous, they dig with their snout and tusks for food. They have bristly coats and a short tail that ends in a long tassel.

MOLUCCAN BABIRUSA
Babyrousa babyrussa
Males of this species have remarkable tusks: the upper canines grow upwards, pierce the snout, and curve backwards. It is native to some Indonesian islands.



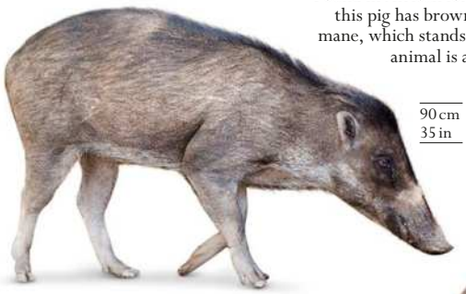
COMMON WARTHOG
Phacochoerus africanus
This pig has a warty face and two pairs of tusks. It often feeds on its front knees when grazing, and runs with its tail erect.

GIANT FOREST HOG
Hylochoerus meinertzhageni
Unlike most pigs, this large, nocturnal wild species from Africa has a thick covering of black and ginger fur.

BUSHPIG
Potamochoerus larvatus
Found in African forests and reedbeds, this pig has brown fur, and a pale mane, which stands upright when the animal is alarmed.

RED RIVER HOG
Potamochoerus porcus
This richly coloured pig from C. Africa has a pair of lumps on its snout, and distinctive white facial markings.

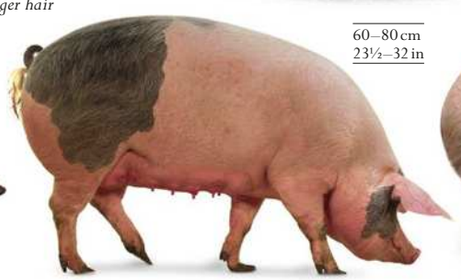
PYGMY HOG
Porcula salvania
Once spread across India and Nepal, this tiny, dark brown pig with a sharply tapered snout is now critically endangered.



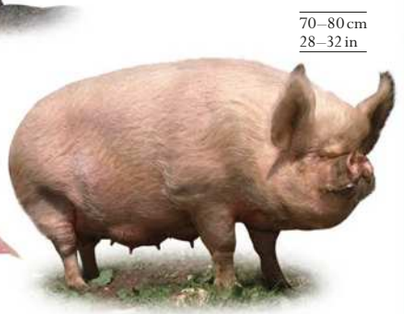
VISAYAN WARTY PIG
Sus cebifrons
Three pairs of fleshy warts on the face protect this boar against the tusks of rival males while fighting.

BEARDED PIG
Sus barbatus
Found in the forests of S.E. Asia, this pig often moves in large herds. It sports a whitish "beard" and distinct tail tassels.

WILD BOAR
Sus scrofa
Widespread in Eurasia, the bristly wild boar is the main ancestor of domestic pigs. The piglets have stripes along the body for camouflage in dense thickets.



PIÉTRAIN PIG
Sus scrofa domesticus
A Belgian domestic breed that produces high-quality, lean meat, this pig has dark spots set within paler blotches on its body.



MIDDLE WHITE PIG
Sus scrofa domesticus
Reared in England for pork, this pig is an unpigmented domestic breed, characterized by its round form and short, upturned nose.

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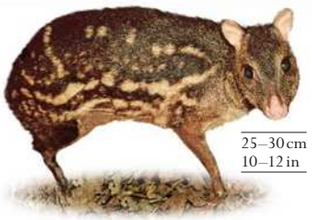
MUSK DEER

Found mainly in Asian montane forests, the solitary, nocturnal members of the family Moschidae are named for the musk gland of adult males. These small, stocky deer have enlarged upper canines and longer hind limbs that help them climb rough terrain.

ALPINE MUSK DEER
Moschus chrysogaster
Inhabiting highland forests from S.E. China to the north of India, this is one of the larger species of musk deer and has long, hare-like ears. The male's musk sac produces musk, which is used to mark territory.

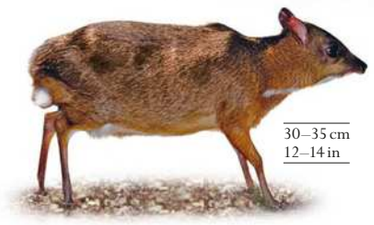
CHEVROTAINS

Found in African and Asian tropical forests, the Tragulidae are somewhat similar to small deer, but lack horns or antlers. In males, the enlarged upper canines project from either side of the lower jaw. Like pigs, chevrotains have four toes on each foot and rather short legs. The stomach is chambered, to ferment and digest tough plant food.



WHITE-SPOTTED CHEVROTAIN
Moschiola meminna
Nocturnal and secretive, this tiny chevrotain from India and Sri Lanka has spots and white stripes on its body.

WATER CHEVROTAIN
Hyemoschus aquaticus
Large and boldly marked with stripes and spots, this chevrotain of W. and C. African forests is a good swimmer and diver.

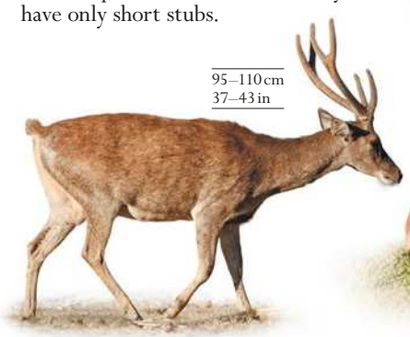


GREATER INDO-MALAYAN CHEVROTAIN
Tragulus napu
Although quite small, this is the largest Asian chevrotain. Its pointed head has dark stripes running from the large eyes to the black nose.

JAVA CHEVROTAIN
Tragulus javanicus
This is the world's smallest hoofed mammal. Its relationship with other chevrotains in Southeast Asian forests is poorly understood.

DEER

Distributed almost globally, the Cervidae are largely absent from Africa and introduced in Australia. They occupy forested and open habitats, but many favour the transitional zones in between. The size and form of the antlers of each species is unique. Unlike permanently horned animals, such as antelopes, male deer shed and regrow their antlers each year; females, with one exception, lack antlers but may have only short stubs.



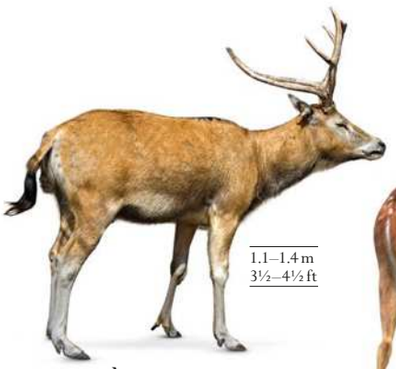
RUSA DEER
Rusa timorensis
This Indonesian forest deer was introduced into arid Australian bushlands, where it thrives. It has large ears and antlers for its size.

SAMBAR
Rusa unicolor
A large, dark brown deer with a prominent mane, the sambar browses in woodlands throughout S. Asia, up to the Himalayan foothills.

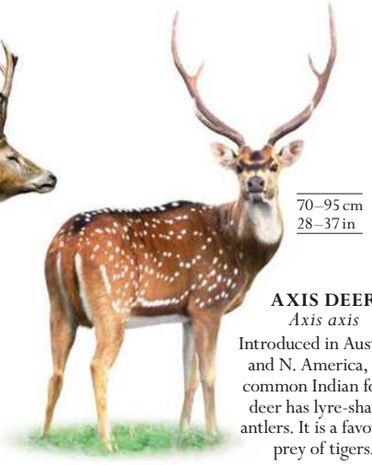
VISAYAN SPOTTED DEER
Rusa alfredi
Endemic to the Philippines, this nocturnal deer has short legs, a distincitve crouching posture, and a dense pattern of pale spots.

REEVES' MUNTJAC
Muntiacus reevesi
Native to eastern Asia, this species was introduced in western Europe. Despite its small size, it damages woodlands by grazing and browsing.

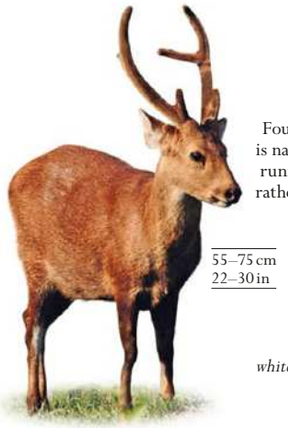
RED MUNTJAC
Muntiacus muntjak
This S. Asian deer uses its short, one-branched antlers and elongated upper canines to defend itself against predators and its territory against rivals.


1.1–1.4 m
3½–4½ ft

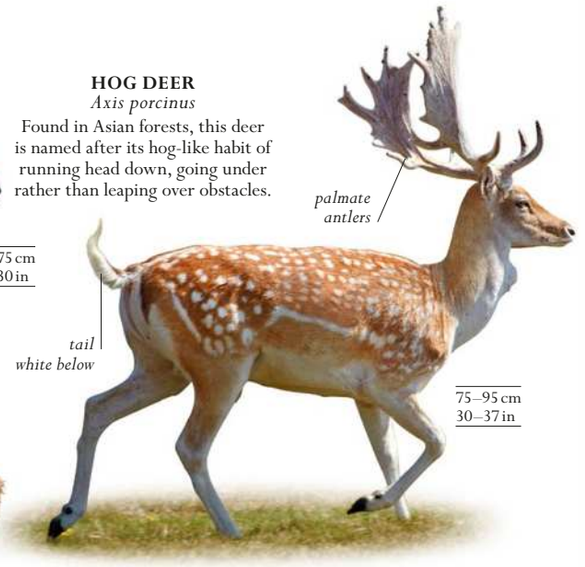
PÈRE DAVID'S DEER
Elaphurus davidianus
Known only from captive populations, this deer was described in 1865 by a French missionary, Father Armand David, and has been reintroduced to China.


70–95 cm
28–37 in

AXIS DEER
Axis axis
Introduced in Australia and N. America, this common Indian forest deer has lyre-shaped antlers. It is a favourite prey of tigers.


55–75 cm
22–30 in

HOG DEER
Axis porcinus
Found in Asian forests, this deer is named after its hog-like habit of running head down, going under rather than leaping over obstacles.


palmate antlers
tail white below
75–95 cm
30–37 in

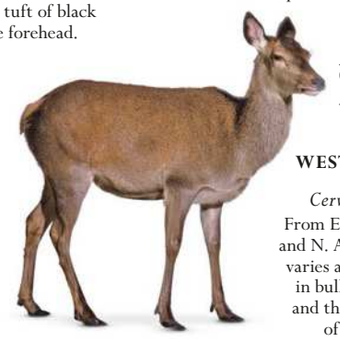
50–70 cm
20–28 in

TUFTED DEER
Elaphodus cephalophus
This small deer lives in Asian montane forests. Males of this species have small antlers and short tusks, with a tuft of black hair on the forehead.

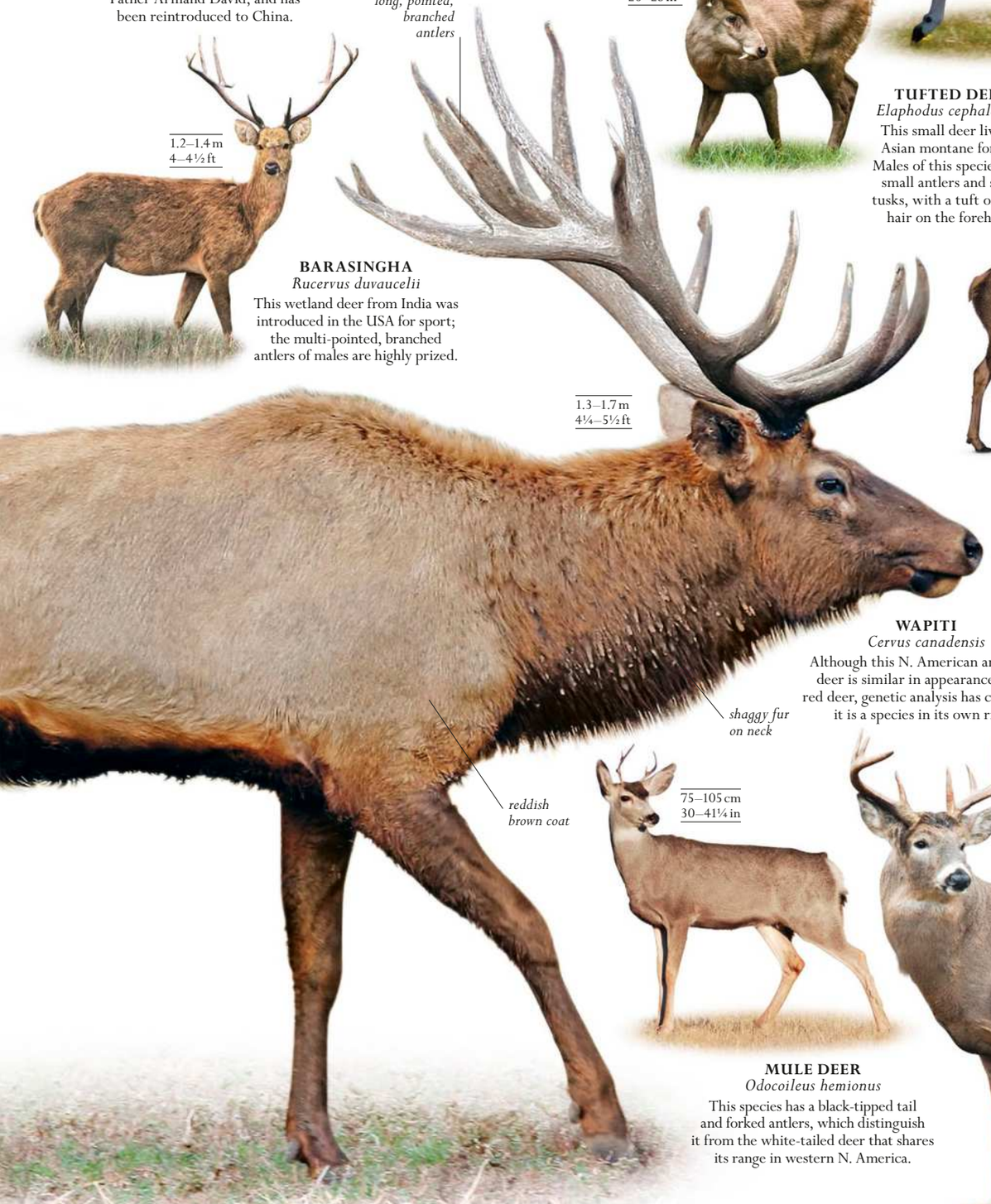
COMMON FALLOW DEER
Dama dama
Often domesticated as a source of venison, this species is distinguished by its spotted coat and flattened, palmate antlers.

1.2–1.4 m
4–4½ ft

BARASINGHA
Rucervus duvaucelii
This wetland deer from India was introduced in the USA for sport; the multi-pointed, branched antlers of males are highly prized.


0.95–1.3 m
3–4¼ ft

WESTERN RED DEER
Cervus elaphus
From Europe, Turkey, and N. Africa, this deer varies across its range in bulk, antler size, and the prominence of its mane.


long, pointed, branched antlers
1.3–1.7 m
4¼–5½ ft
shaggy fur on neck
reddish brown coat

WAPITI
Cervus canadensis
Although this N. American and Asian deer is similar in appearance to the red deer, genetic analysis has confirmed it is a species in its own right.

60–115 cm
23½–45 in

SIKA DEER
Cervus nippon
Distinguished by its stout, upright antlers, the sika breeds with red deer, especially when introduced outside its native E. Asia.

75–105 cm
30–41¼ in

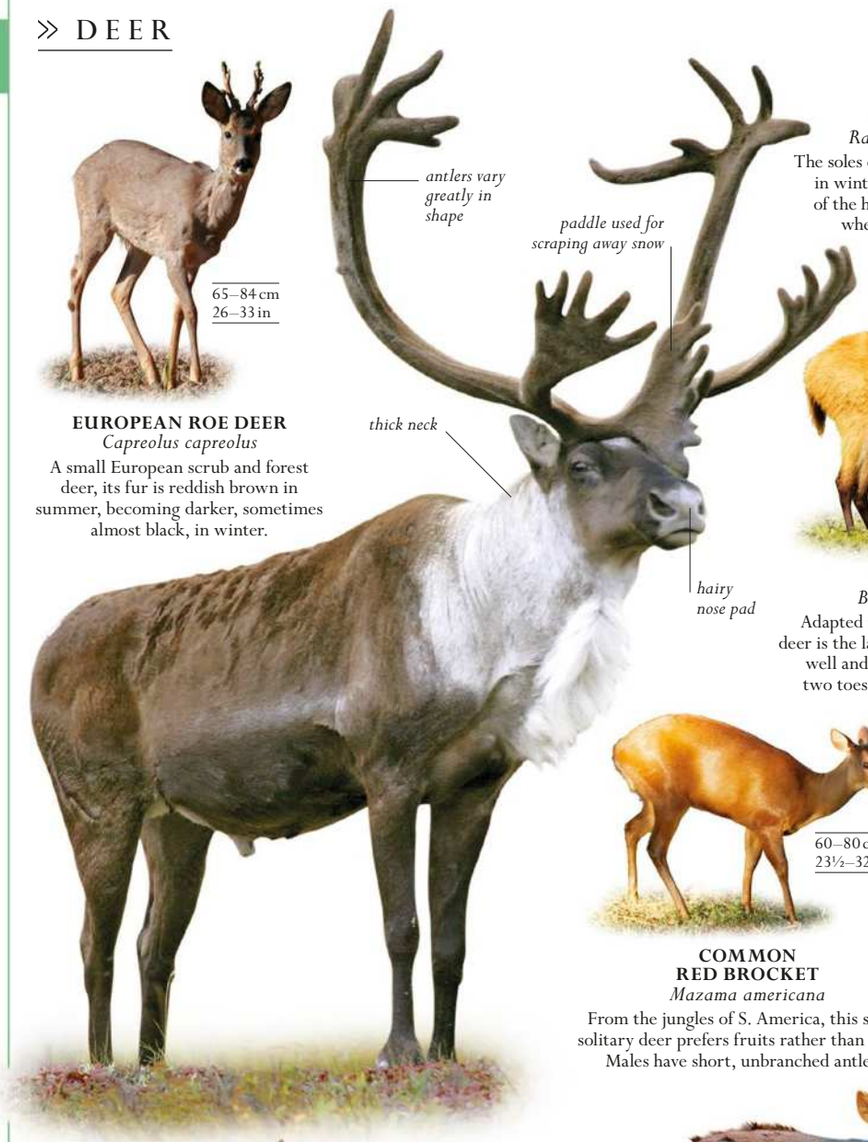
MULE DEER
Odocoileus hemionus
This species has a black-tipped tail and forked antlers, which distinguish it from the white-tailed deer that shares its range in western N. America.

55–105 cm
22–41¼ in
greyish brown coat

WHITE-TAILED DEER
Odocoileus virginianus
Found from Canada to Peru, and introduced in Europe and New Zealand, this deer flashes the white underside of its tail when alarmed.

» DEER

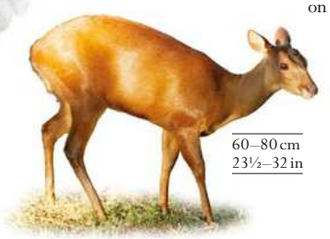
EUROPEAN ROE DEER
Capreolus capreolus
A small European scrub and forest deer, its fur is reddish brown in summer, becoming darker, sometimes almost black, in winter.



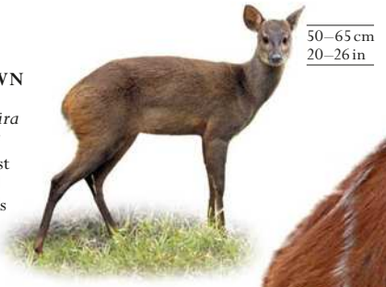
REINDEER
Rangifer tarandus
The soles of this deer's feet shrink in winter. The exposed rims of the hoofs provide traction when walking on ice.

MARSH DEER
Blastocerus dichotomus
Adapted to wetland habitats, the marsh deer is the largest S. American deer. It swims well and has a membrane between the two toes of each foot that aids walking on soft ground.

MOOSE
Alces americanus
The world's largest deer, inhabiting the forests of N. America, the male's palmate antlers may span 2 m (6½ ft) and each has up to 20 points.



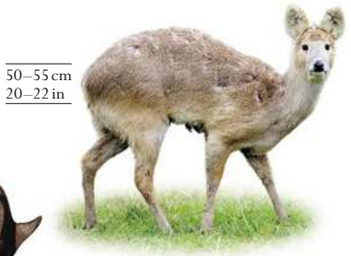
COMMON RED BROCKET
Mazama americana
From the jungles of S. America, this small, solitary deer prefers fruits rather than leaves. Males have short, unbranched antlers.



COMMON BROWN BROCKET
Mazama gouazoubira
A solitary deer of scrubland and forest thickets in C. and S. America, it feeds mainly on fruits, and cacti during the dry season.

PAMPAS DEER
Ozotoceros bezoarticus
A slender deer of S. American grasslands and wetlands, the pampas deer stands on its hind legs to browse from tree branches.

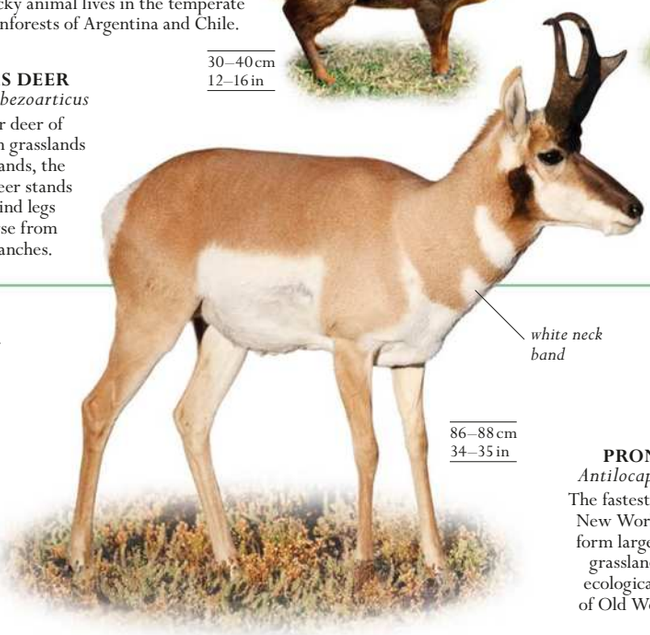
SOUTHERN PUDU
Pudu puda
One of the world's smallest deer, this stocky animal lives in the temperate rainforests of Argentina and Chile.



CHINESE WATER DEER
Hydropotes inermis
Uniquely among deer, neither sex grows antlers. Their long upper canines protrude as tusks, up to 8 cm (3¼ in) long in males.

PRONGHORN

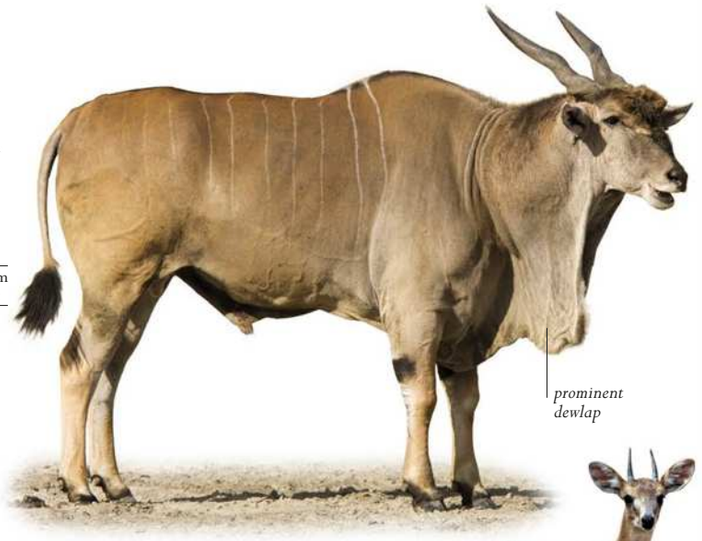
Widely represented in the North American fossil record, the Antilocapridae included species with bizarrely shaped or multiple horns. Today only the pronghorn survives. With a similar body shape and cloven hoofs, the pronghorn resembles antelopes (Bovidae), but unlike them it lacks lateral toes and sheds its horns outside the breeding season.



PRONGHORN
Antilocapra americana
The fastest mammal in the New World, pronghorns form large herds in open grassland and are the ecological counterpart of Old World antelopes.

BOVIDS

A large and varied family, the Bovidae are found on all continents except Antarctica. Despite their diversity, they share common features: males (and in some species, females) have permanent unbranched horns, often twisted or fluted, and a complex, four-chambered, ruminant's stomach.



COMMON ELAND
Taurotragus oryx
With spiral horns, the eland is the largest antelope, found in open grassland from Ethiopia to South Africa. Males sometimes develop white stripes down their flanks.

1.3–1.8m
4¼–6 ft

1.2–1.4 m
4–4½ ft

NILGAI
Boselaphus tragocamelus
The largest Asian antelope, with a robust body sloping down from the shoulder, male nilgai develop a blue-grey coat; females are yellow-brown in colour.

1.2–1.3 m
4–4¼ ft

BONGO
Tragelaphus eurycerus
Well camouflaged in the dense forests of W. and C. Africa, female bongos are usually more brightly coloured than the males. Both sexes have spiral horns.

55–66 cm
22–26 in

FOUR-HORNED ANTELOPE
Tetracerus quadricornis
This solitary Asian forest species usually develops two pairs of horns: one between the ears and the other on the forehead.

82–121 cm
32–47½ in

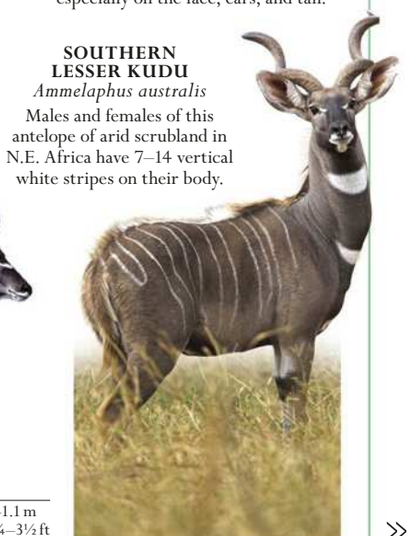
NYALA
Tragelaphus angasii
This southern African forest antelope has spiral horns and a dark brown coat, with vertical white stripes on the sides.

61–100 cm
23¾–39 in

CAPE BUSHBUCK
Tragelaphus sylvaticus
Widespread in sub-Saharan forests, this species has varied stripes and spots, especially on the face, ears, and tail.

0.9–1.3 m
3–4¼ ft

ZAMBEZI SITATUNGA
Tragelaphus selousi
Inhabiting southern African swamps, this excellent swimmer will often take refuge in pools of water when threatened by a predator.

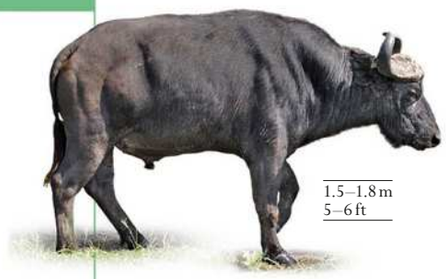


SOUTHERN LESSER KUDU
Ammelaphus australis
Males and females of this antelope of arid scrubland in N.E. Africa have 7–14 vertical white stripes on their body.

1.2–1.6 m
4–5¼ ft

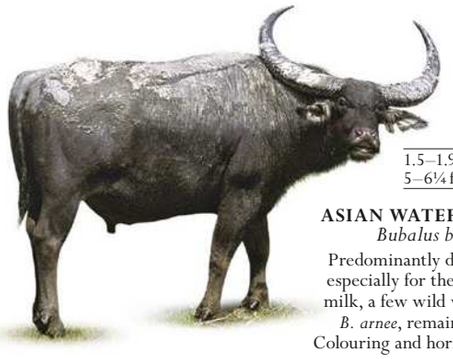
ZAMBEZI KUDU
Strepsiceros zambesiensis
Male Zambezi kudu have some of the most magnificent horns of any antelope, with two and a half twists when fully grown.

1–1.1 m
3¼–3½ ft



1.5–1.8 m
5–6 ft

AFRICAN BUFFALO
Syncerus caffer
Unpredictable and dangerous, this buffalo cannot be domesticated. Grassland forms have more curved horns than the smaller forest-dwellers.



1.5–1.9 m
5–6¼ ft

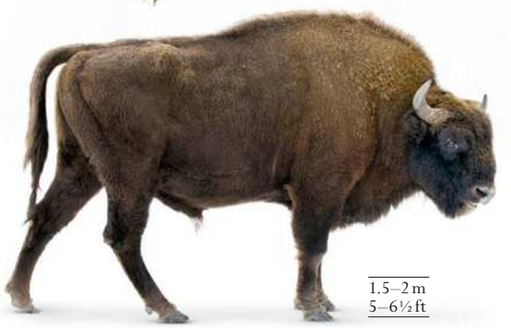
ASIAN WATER BUFFALO
Bubalus bubalis
Predominantly domesticated, especially for their power and milk, a few wild water buffalo, *B. arnee*, remain in S. Asia. Colouring and horns are variable.

60–100 cm
23½–39 in

LOWLAND ANOA
Bubalus depressicornis
The smallest of all wild cattle, native to the rainforests of Sulawesi, the horns are straight and upright compared with other buffalo.

1.5–2 m
5–6½ ft

AMERICAN BISON
Bison bison
Once roaming N. America in huge herds, the few remaining wild bison are dwarfed by captive populations raised for meat and hides.



1.5–2 m
5–6½ ft

WISENT
Bison bonasus
With shorter hair but longer horns than the American bison, this species is now restricted to E. European and Russian primary forests.

1.6 m
5¼ ft

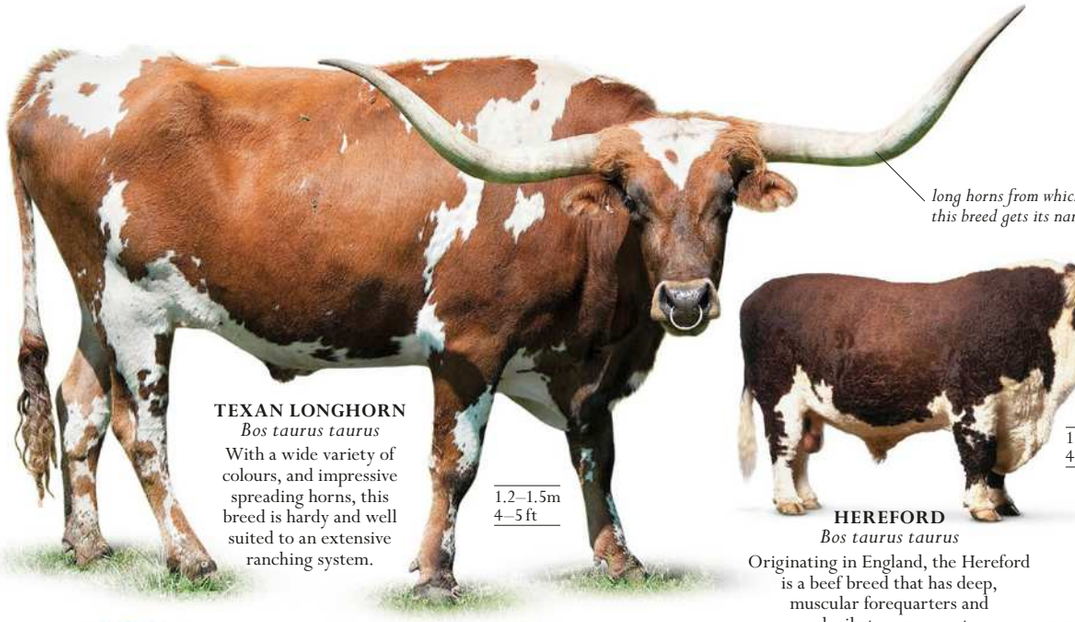
BANTENG
Bos javanicus
Native to S.E. Asia and domesticated locally as draught animals, this bovid is brown, with white lower legs, muzzle, rump, and eye spots.

1.4–2 m
4½–6½ ft

YAK
Bos mutus
Inhabiting montane parts of C. Asia, insulated with long, shaggy fur, wild yaks have a dark coat, but domesticated ones are more varied and often have white markings.

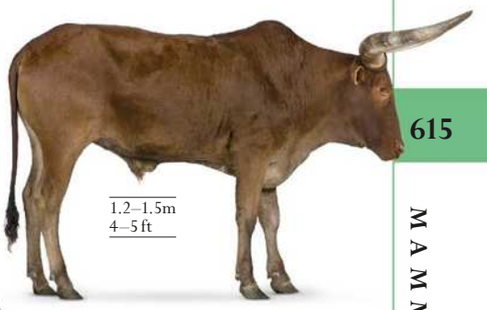
1.7–2.2 m
5½–7¼ ft

GAUR
Bos gaurus
The largest species of wild cattle, this muscular Asian forest bovine is dark brown, but paler on the muzzle and lower legs.



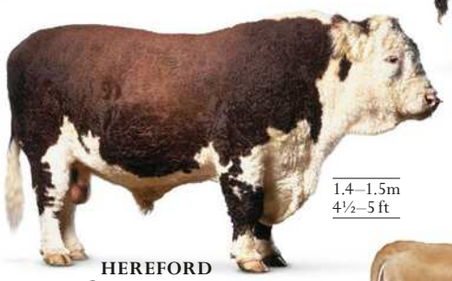
TEXAN LONGHORN
Bos taurus taurus
With a wide variety of colours, and impressive spreading horns, this breed is hardy and well suited to an extensive ranching system.

1.2–1.5m
4–5 ft



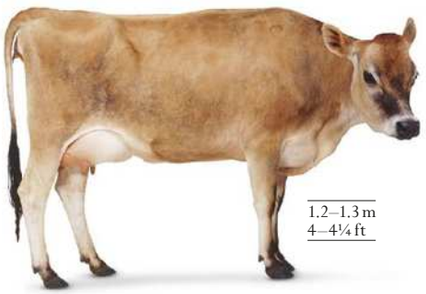
1.2–1.5m
4–5 ft

ANKOLE
Bos taurus taurus
Originating in Africa, the ankole's huge horns, up to 1.8 m (3½ ft) long and very thick, help to keep it cool in hot conditions.



1.4–1.5m
4½–5 ft

HEREFORD
Bos taurus taurus
Originating in England, the Hereford is a beef breed that has deep, muscular forequarters and a docile temperament.



1.2–1.3 m
4–4¼ ft

JERSEY
Bos taurus taurus
Famed for its rich, creamy milk, this breed was developed on the island of Jersey from stock imported from France.

35–42 cm
14–16½ in

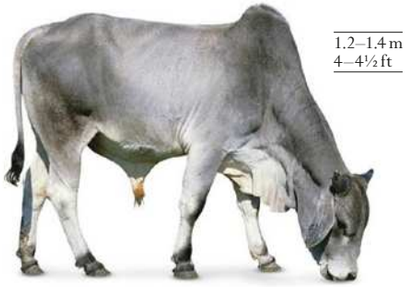
MAXWELL'S DUIKER
Philantomba maxwellii
With a grey-brown coat, this small W. African rainforest species has few distinctive features, apart from its pale facial markings.

30–40 cm
12–16 in

ZIMBABWE BLUE DUIKER
Philantomba bicolor
This small forest antelope from S.E. Africa has simple conical horns. It eats mainly newly fallen leaves, fruits, and seeds, but also insects and fungi when available.

40–50 cm
16–20 in

ZEBRA DUIKER
Cephalophus zebra
This is the only duiker without a predominantly plain coat. The stripes provide camouflage in its W. African forest-edge habitat.



1.2–1.4 m
4–4½ ft

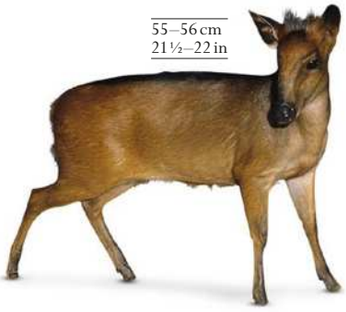
BRAHMAN
Bos taurus indicus
Originating in Asia, the brahman is now farmed throughout the tropics. Also known as the zebu, it has a characteristic hump on the back.

65–85 cm
26–34 in

WESTERN YELLOW-BACKED DUIKER
Cephalophus silvicultor
Found from west to central Africa, this large duiker has a dark grey coat with a conspicuous white or yellow patch on the back.

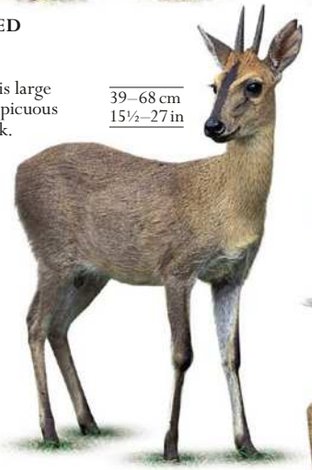
54–58 cm
21½–23 in

BLACK-FRONTED DUIKER
Cephalophus nigrifrons
A dark forehead and eye glands, contrasting with paler brows, give this forest dweller from C. Africa a distinctive facial appearance.



55–56 cm
21½–22 in

OGILBY'S DUIKER
Cephalophus ogilbyi
From the rainforests of W. Africa, this duiker has well-developed hindquarters, with a red-brown rump.

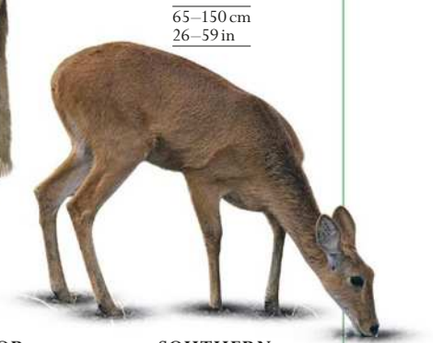


39–68 cm
15½–27 in

COMMON DUIKER
Sylvicapra grimmia
A widespread sub-Saharan antelope with tiny horns, this species occupies a wide range of habitats, often scavenging on fallen fruit.

69–89 cm
27–35 in

BOHOR REEDBUCK
Redunca bohor
Ranging across rolling grassland in C. Africa, the slender female of this species contrasts with the thick-necked, horned male.



65–150 cm
26–59 in

SOUTHERN REEDBUCK
Redunca arundinum
A robust antelope in grasslands in southern C. Africa, this species has conspicuous black foreleg markings. Only the males have horns.

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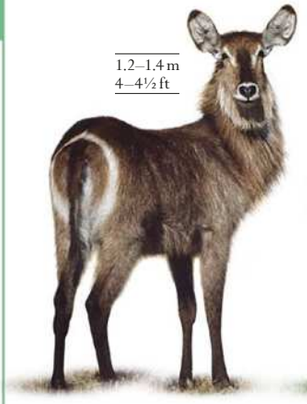
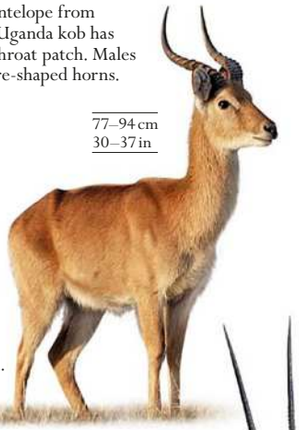


COMMON WATERBUCK
Kobus ellipsiprymnus ellipsiprymnus
Despite its name, this African waterbuck is a savanna and woodland antelope, although it will seek refuge from predators in water.

DEFASSA WATERBUCK
Kobus ellipsiprymnus defassa
From W. and C. Africa, this subspecies of waterbuck has a solid white rump, rather than a white crescent surrounding the tail.

RED LECHWE
Kobus leche
A highly gregarious antelope, favouring southern C. African marshlands, its long legs enable the lechwe to run well through shallow water.

UGANDA KOB
Kobus thomasi
A sociable antelope from E. Africa, the Uganda kob has a distinct white throat patch. Males have ridged, lyre-shaped horns.

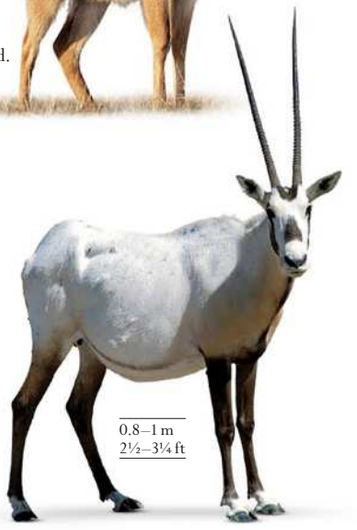


PUKU
Kobus vardonii
Very similar to the kob, but from southern C. Africa, the puku is slightly smaller and more stockily proportioned.

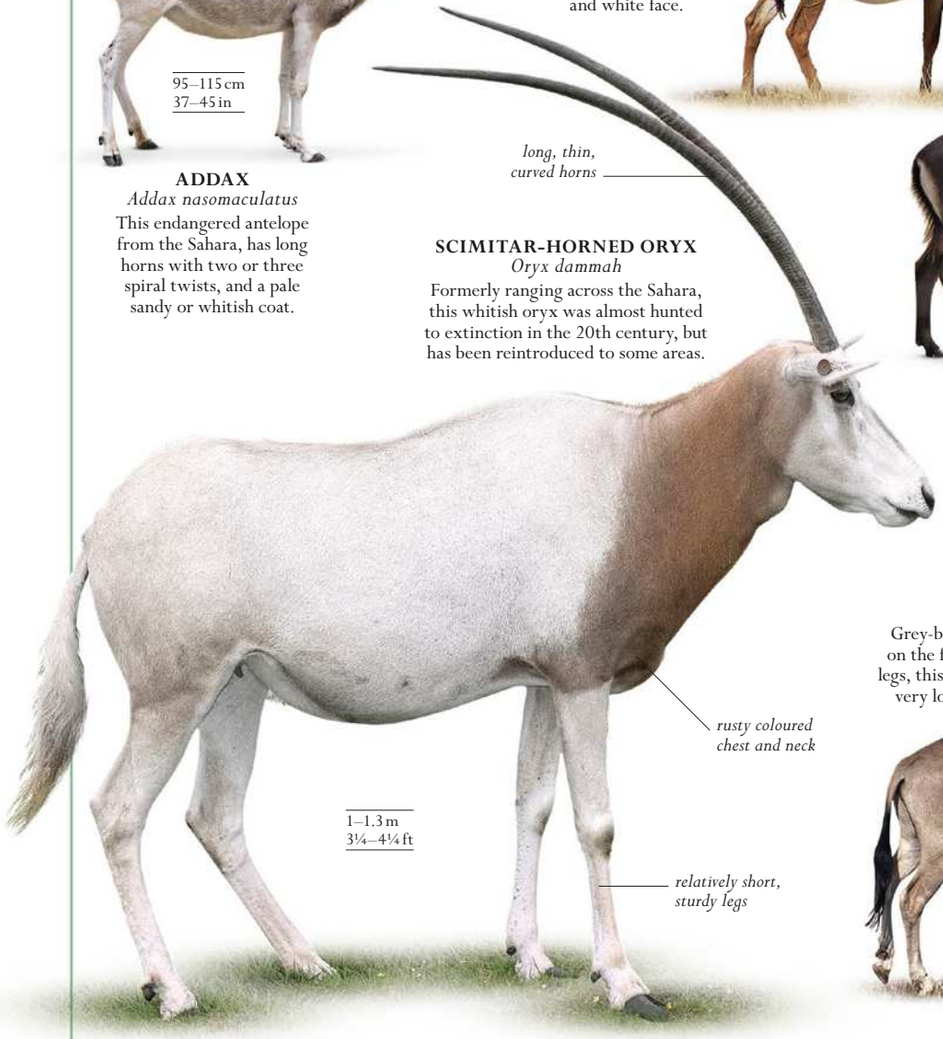
ADDAX
Addax nasomaculatus
This endangered antelope from the Sahara, has long horns with two or three spiral twists, and a pale sandy or whitish coat.

ROAN ANTELOPE
Hippotragus equinus
The ridged horns of this sub-Saharan savanna antelope grow in a smooth curve. The animal has a distinctive black and white face.

SOUTHERN SABLE ANTELOPE
Hippotragus niger
A powerful antelope with a dark coat and striking white face markings, its magnificent horns can reach more than a metre (3¼ ft) in length.



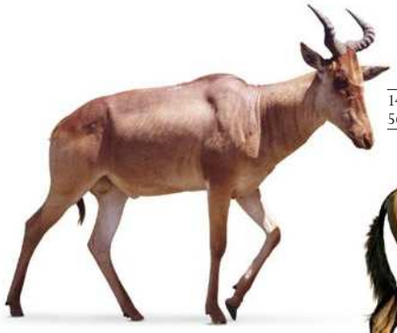
ARABIAN ORYX
Oryx leucoryx
White-coated,with long, straight horns, this antelope has recently been reintroduced to parts of its former Middle Eastern range.



SCIMITAR-HORNED ORYX
Oryx dammah
Formerly ranging across the Sahara, this whitish oryx was almost hunted to extinction in the 20th century, but has been reintroduced to some areas.

GALLA ORYX
Oryx gallarum
Grey-brown, marked with black on the face, tail, flanks, and front legs, this E. African desert oryx has very long, barely curved horns.

GEMSBOK
Oryx gazella
The largest oryx, the gemsbok frequents arid habitats in southern Africa, but has also been successfully established in N. America.

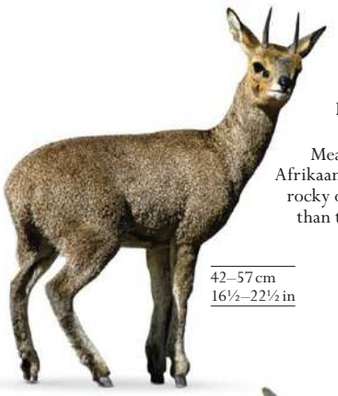


143 cm
56 in

WESTERN HARTEBEEST
Alcelaphus major
A large, long-faced antelope that lives on open grassland in E. Africa. Hartebeest species differ in their coloration and horn shape.

1.2–1.3 m
4–4¼ ft

RED HARTEBEEST
Alcelaphus caama
Chestnut brown in colour, with a darker face and tail, this antelope is most active at dawn and dusk.



KLIPSPRINGER
Oreotragus sp.
Meaning "rock jumper" in Afrikaans, the klipspringer inhabits rocky outcrops. It can leap more than ten times its own height.

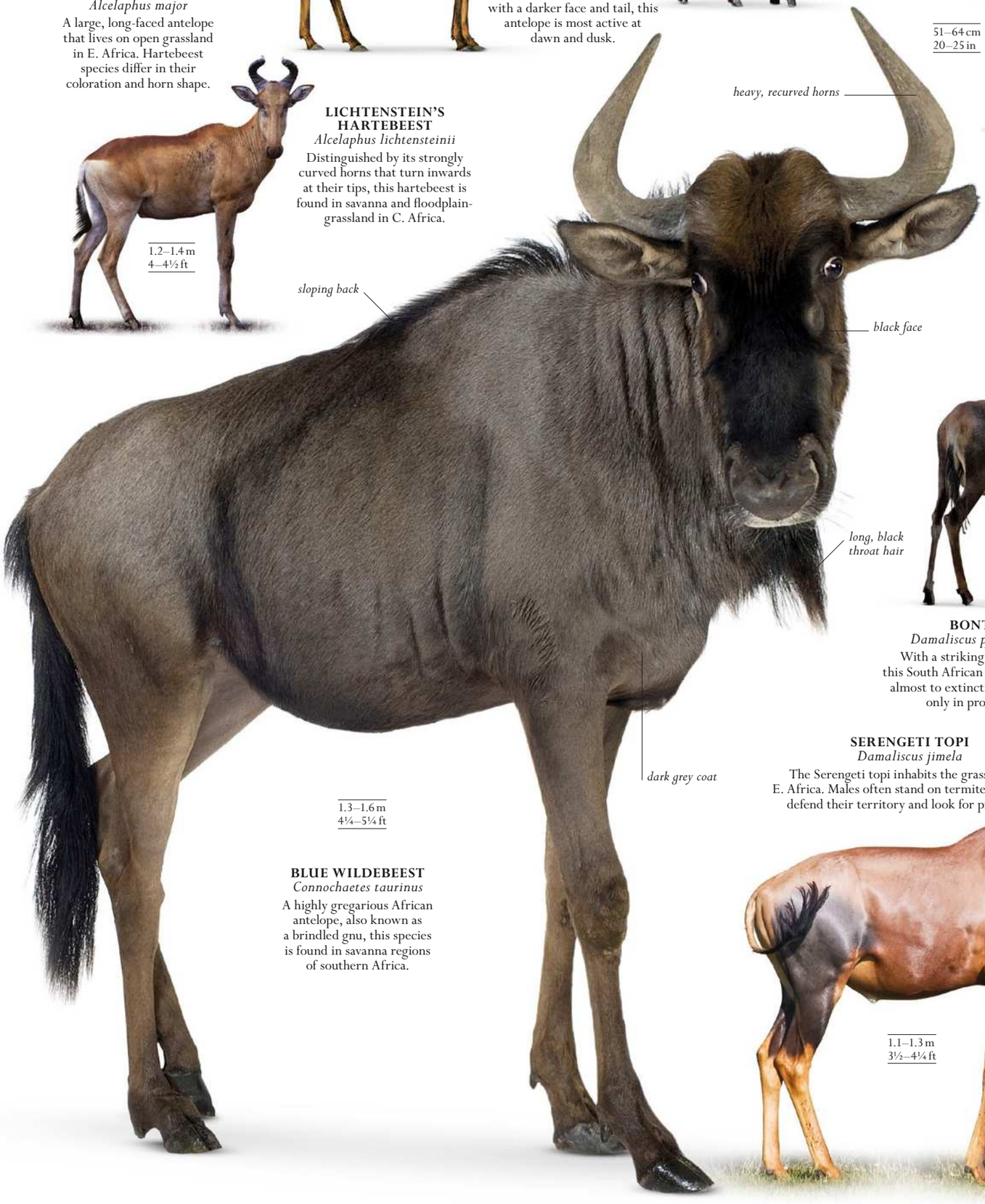
42–57 cm
16½–22½ in

51–64 cm
20–25 in

CENTRAL ORIBI
Ourebia hastata
This graceful, long-necked antelope from E. Africa west to Angola has a distinctive white brow line and a large, dark facial gland.

1.2–1.4 m
4–4½ ft

LICHTENSTEIN'S HARTEBEEST
Alcelaphus lichtensteinii
Distinguished by its strongly curved horns that turn inwards at their tips, this hartebeest is found in savanna and floodplain-grassland in C. Africa.



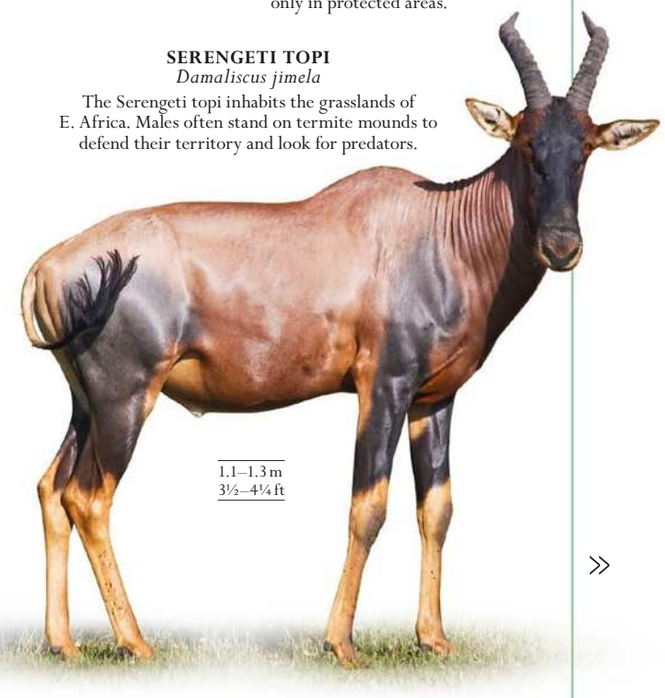
1.3–1.6 m
4¼–5¼ ft

BLUE WILDEBEEST
Connochaetes taurinus
A highly gregarious African antelope, also known as a brindled gnu, this species is found in savanna regions of southern Africa.

80–100 cm
32–39 in

BONTEBOK
Damaliscus pygargus dorcas
With a striking white face patch, this South African antelope was hunted almost to extinction. It is now found only in protected areas.

SERENGETI TOPI
Damaliscus jimela
The Serengeti topi inhabits the grasslands of E. Africa. Males often stand on termite mounds to defend their territory and look for predators.



1.1–1.3 m
3½–4¼ ft

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77–87 cm
30–34 in

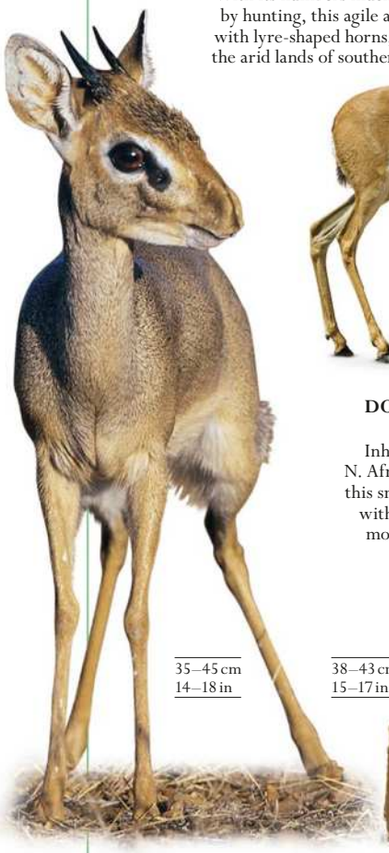
KALAHARI SPRINGBOK
Antidorcas hofmeyi
With its numbers much reduced by hunting, this agile antelope, with lyre-shaped horns, browses the arid lands of southern Africa.

53–67 cm
21–26 in

SERENGETI THOMSON'S GAZELLE
Eudorcas nasalis
The most numerous gazelle on the plains of E. Africa, this species has a broad black stripe on its sides.

60–85 cm
23½–34 in

BLACKBUCK
Antilope cervicapra
With the ability to reach speeds of 80 kph (50 mph), the blackbuck inhabits grassland and open woodland in India and Pakistan.


35–45 cm
14–18 in

55–65 cm
22–26 in

DORCAS GAZELLE
Gazella dorcas
Inhabiting deserts from N. Africa to the Middle East, this small gazelle can survive without drinking, taking moisture from its food.

60–65 cm
23½–26 in

MOUNTAIN GAZELLE
Gazella gazella
From the mountains and plains of the Middle East, this gazelle has several isolated subspecies, some extremely rare and threatened by poaching.

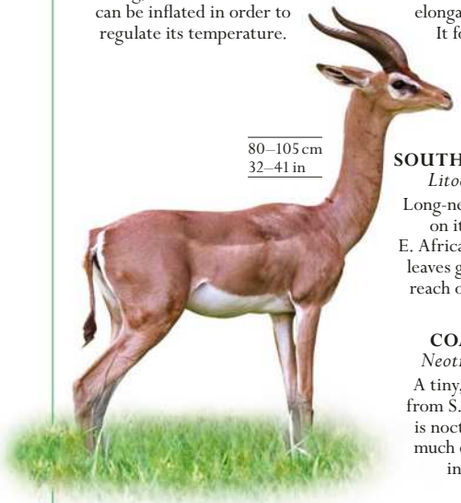
38–43 cm
15–17 in

GÜNTHER'S DIK-DIK
Madoqua guentheri
A dik-dik of the E. African semi-deserts, this species has a long, elastic muzzle that can be inflated in order to regulate its temperature.

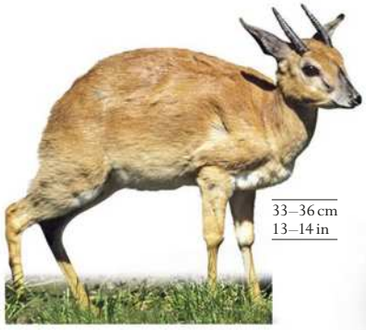
DAMARA DIK-DIK
Madoqua damarensis
A tiny antelope, named for its sharp alarm note, the Damara dik-dik has an elongated, mobile snout. It forms territorial pairs.

57–79 cm
22½–31 in

WESTERN SAIGA
Saiga tatarica
Now highly endangered and found only in western Asia, this saiga's enlarged, flexible nose warms cold winter air and filters out summer dust.


80–105 cm
32–41 in

SOUTHERN GERENUK
Litocranius walleri
Long-necked and standing on its hind legs, the E. African gerenuk browses leaves growing out of the reach of other antelopes.

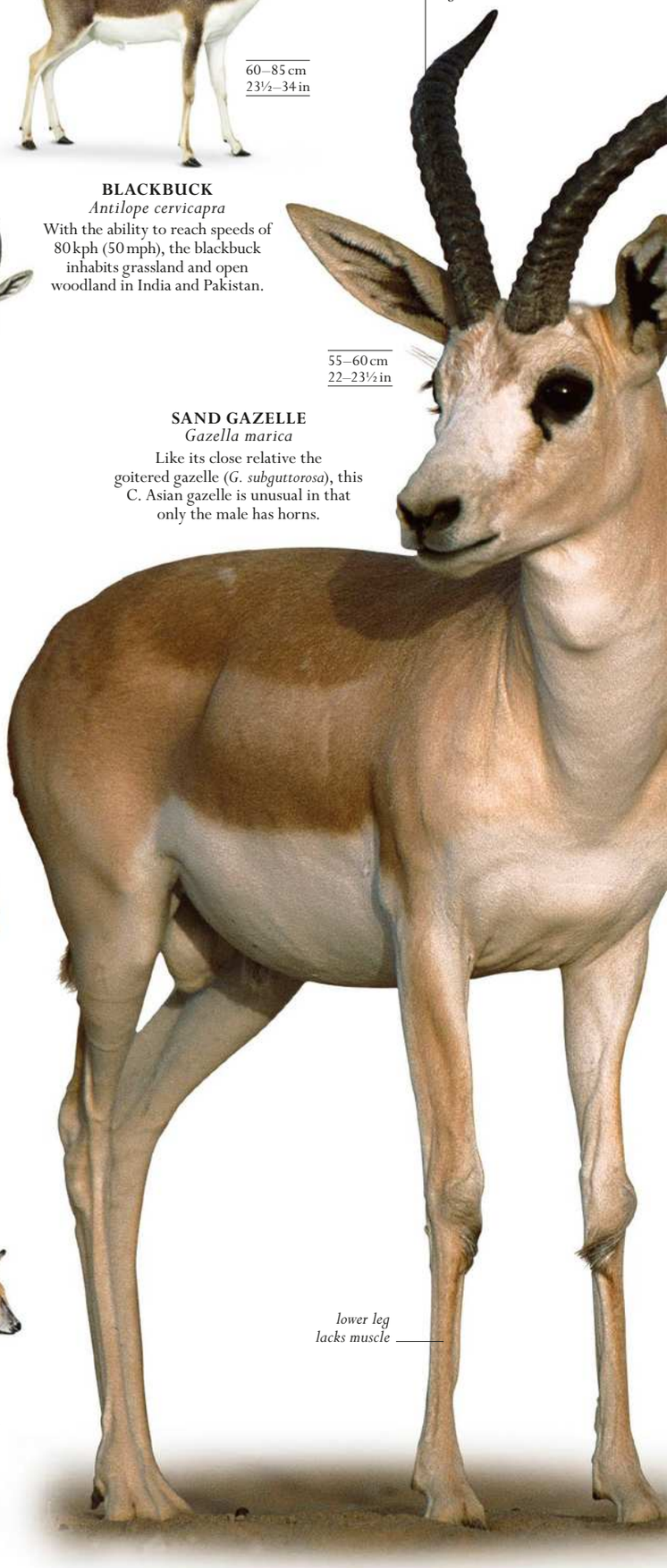

33–36 cm
13–14 in

COASTAL SUNI
Neotragus moschatus
A tiny, reddish antelope from S.E. Africa, the suni is nocturnal and spends much of its time hidden in dense scrub.

strongly ridged horns

55–60 cm
22–23½ in

SAND GAZELLE
Gazella marica
Like its close relative the goitered gazelle (*G. subguttorosa*), this C. Asian gazelle is unusual in that only the male has horns.



lower leg lacks muscle

1–1.2 m
3¼–4 ft

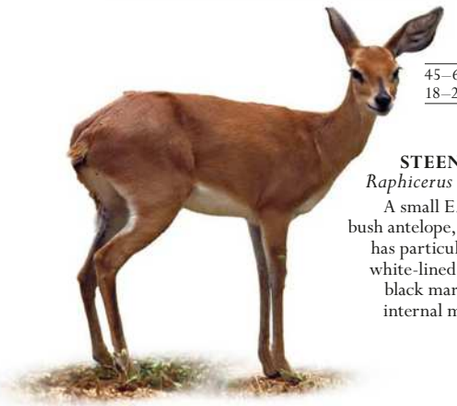
DAMA GAZELLE
Nanger dama
This rare Saharan gazelle is strikingly bicoloured. The amount of white varies between subspecies, although all have a white throat patch.

75–94 cm
30–37 in

GRANT'S GAZELLE
Nanger granti
Frequenting the E. African plains, this gazelle can survive without drinking water, and so does not follow the migrations of many of its relatives.

60–90 cm
24–35 in

SOEMMERRING'S GAZELLE
Nanger soemmerringii
Similar to, but much rarer than Grant's gazelle, this E. African species is distinguished by its stronger face pattern and larger white rump patch.

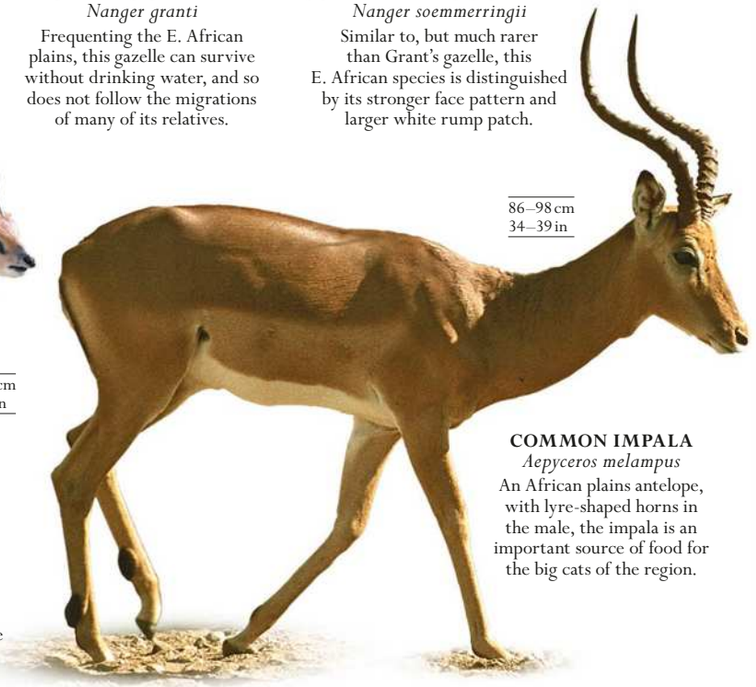


45–60 cm
18–23½ in

STEENBOK
Raphicerus campestris
A small E. African bush antelope, the steenbok has particularly large, white-lined ears, with black margins and internal markings.

45–60 cm
18–24 in

SHARPE'S GRYSBOK
Raphicerus sharpei
Shy and solitary, with stubby horns, this nocturnal antelope from eastern Africa takes refuge from predators in the burrows of aardvarks.

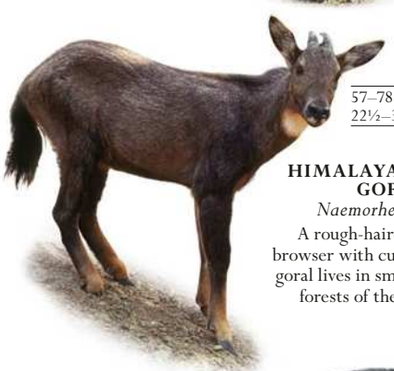


86–98 cm
34–39 in

COMMON IMPALA
Aepyceros melampus
An African plains antelope, with lyre-shaped horns in the male, the impala is an important source of food for the big cats of the region.

70–85 cm
28–34 in

ALPINE CHAMOIS
Rupicapra rupicapra
Living high among mountain rocks in the upland blocks of S. Europe and Asia Minor, this species occurs in isolated populations. Each has a subtly different appearance.



57–78 cm
22½–31 in

HIMALAYAN BROWN GORAL
Naemorhedus goral
A rough-haired, goat-like browser with curved horns, the goral lives in small herds in the forests of the Himalayas.

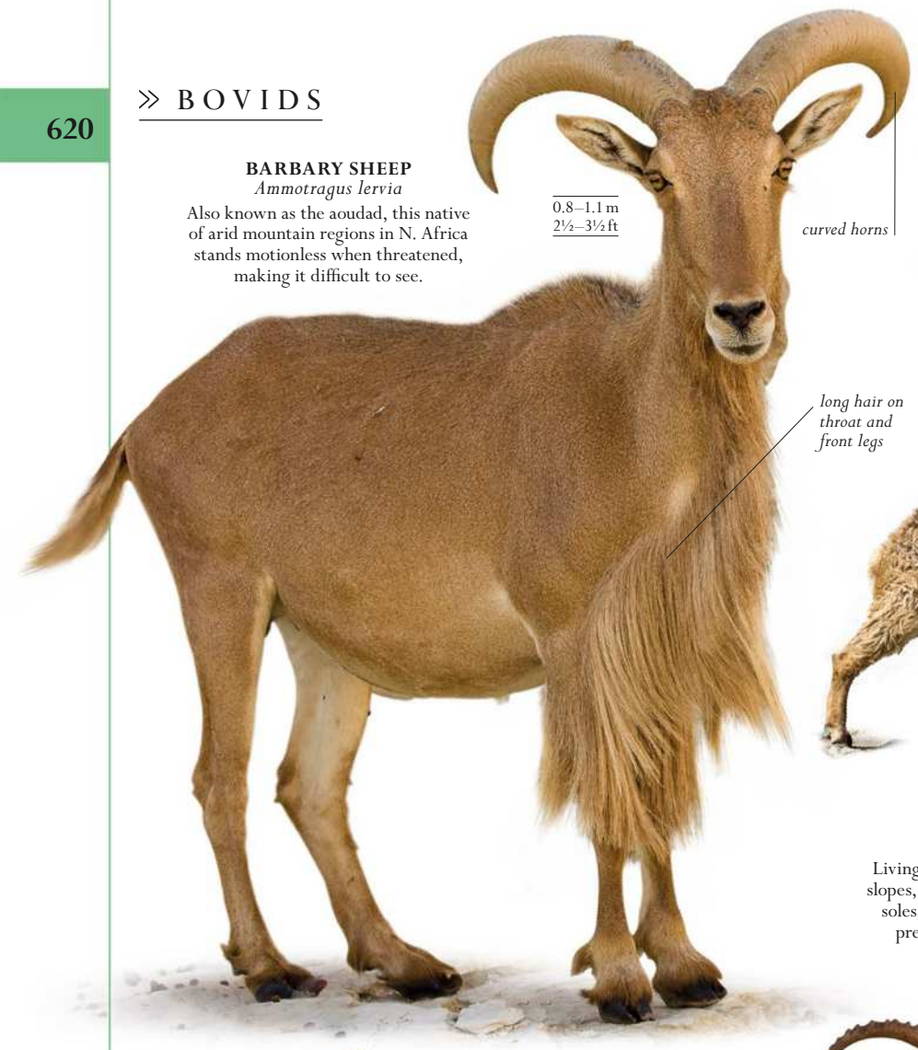
85–94 cm
34–37 in

INDOCHINESE SEROW
Capricornis maritimus
A goat-antelope, with coarse fur and a distinct mane, the Indochinese serow is a browser of leaves and shoots and sometimes a little grass.

white coat has dense underfur for warmth

0.9–1.1 m
3–3½ ft

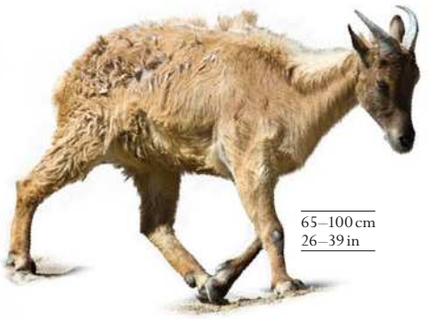
MOUNTAIN GOAT
Oreamnos americanus
A sure-footed climber from the northern Rocky Mountains, this goat has a dense, woolly white coat to protect it from low temperatures and high winds.



BARBARY SHEEP
Ammotragus lervia
Also known as the aoudad, this native of arid mountain regions in N. Africa stands motionless when threatened, making it difficult to see.

MUSKOX
Ovibos moschatus
An inhabitant of Arctic tundra, the muskox has a shaggy coat, with dense insulating underwool, which provides protection against the elements.

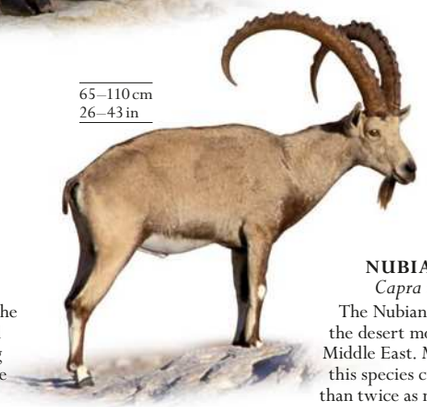
BHUTAN TAKIN
Budorcas whitei
Living in small herds in the mountain forests of N.E. India, China, and Bhutan, the Bhutan takin has shaggy fur and a broad, arched muzzle.



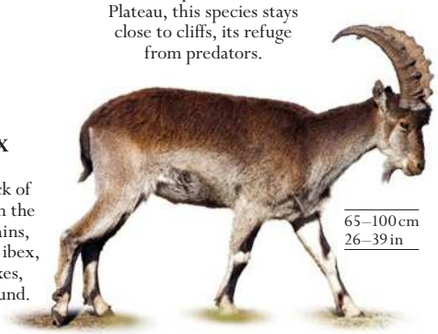
HIMALAYAN TAHR
Hemitragus jemlahicus
Living on rocky Himalayan mountain slopes, the tahr has hoofs with rubbery soles, which give additional grip on precipitous or unstable ground.

BHARAL
Pseudois nayaur
From rocky deserts to mountain slopes on the Tibetan Plateau, this species stays close to cliffs, its refuge from predators.

ALPINE IBEX
Capra ibex
Living above the tree line in the Alps, this ibex has recurved horns up to 1 m (3¼ ft) long that are especially impressive on males.



NUBIAN IBEX
Capra nubiana
The Nubian ibex inhabits the desert mountains of the Middle East. Mature males of this species can weigh more than twice as much as females.



WALIA IBEX
Capra walie
Due to the the lack of seasonal changes in the Ethiopian mountains, this rare species of ibex, unlike other ibexes, breeds all year round.

MARKHOR
Capra falconeri
The largest wild goat, from the mountains of C. Asia, is endangered. It is hunted for its impressive corkscrew horns and meat.

ANGORA GOAT
Capra hircus
This breed of goat, originating in Turkey, has a fleece that is much valued as the source of mohair, a durable silky fibre.

BAGOT GOAT
Capra hircus
One of more than 300 goat breeds, the Bagot was bred in England from stock brought home in the 13th century by the returning Crusaders.

GOLDEN GUERNSEY GOAT
Capra hircus
A small goat, often with long hair, this rare breed is kept for milk and showing and originated on Guernsey in the Channel Islands.

90–100 cm
35–39 in

MOUFLON
Ovis aries orientalis

With a reddish coat and pale saddle, this native of Asia Minor has been established on several Mediterranean islands since Neolithic times.

65–80 cm
26–32 in

MANX LOAGHTAN SHEEP
Ovis aries

Originating on the Isle of Man, this primitive, hardy breed, kept for its meat, has brown wool and usually four horns.

65–100 cm
26–39 in

COTSWOLD SHEEP
Ovis aries

Originating in England, this white-faced breed is hardy and dual-purpose, kept for its long wool and its meat.

65–80 cm
26–32 in

JACOB SHEEP
Ovis aries

This ancient, hardy breed, with a patterned coat, is said to have originated in Palestine. It has as many as three pairs of horns.

0.9–1.2 m
3–4 ft

♀

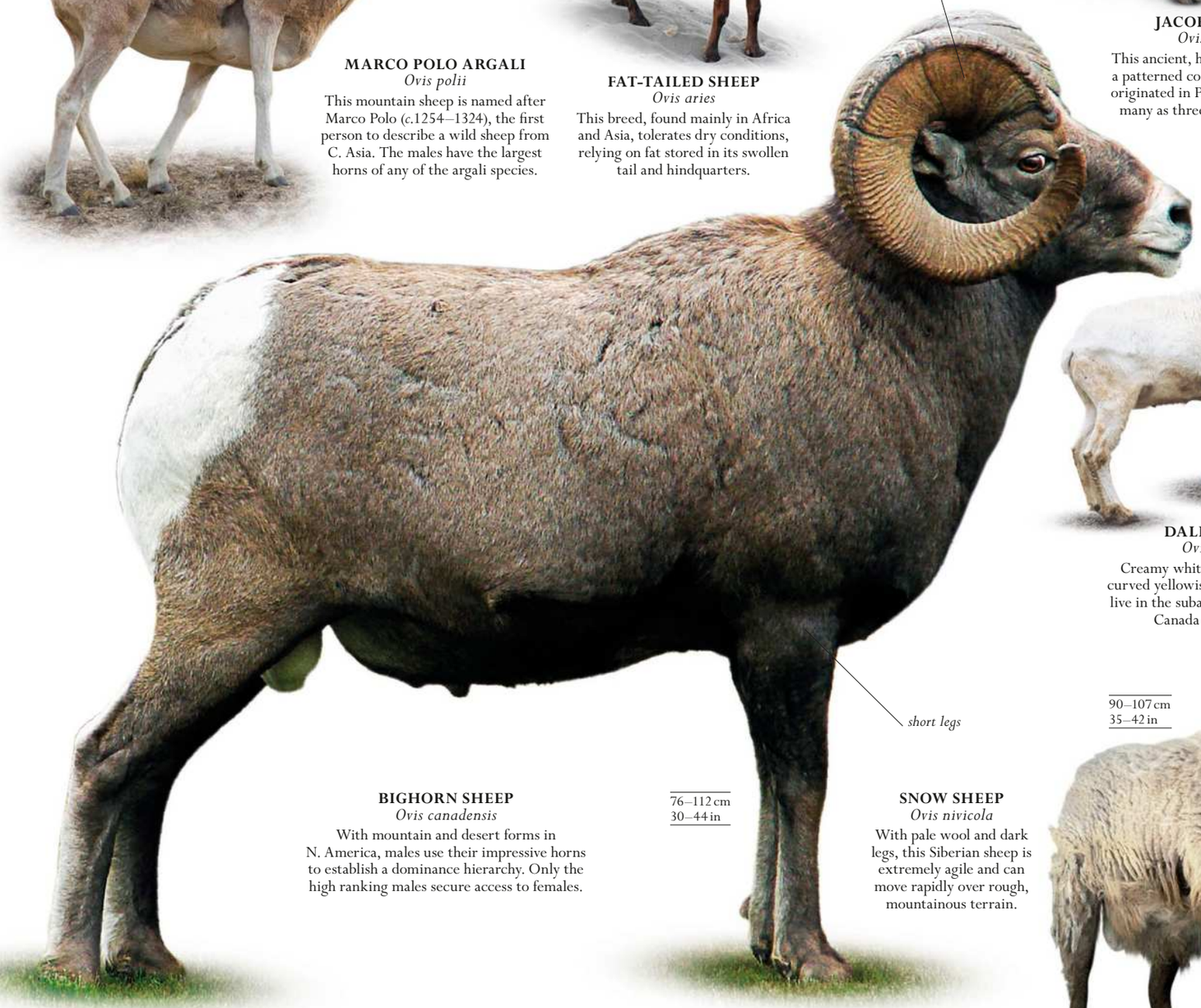
MARCO POLO ARGALI
Ovis polii

This mountain sheep is named after Marco Polo (*c.*1254–1324), the first person to describe a wild sheep from C. Asia. The males have the largest horns of any of the argali species.

65–110 cm
26–43 in

FAT-TAILED SHEEP
Ovis aries

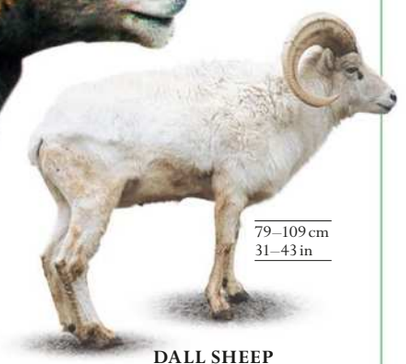
This breed, found mainly in Africa and Asia, tolerates dry conditions, relying on fat stored in its swollen tail and hindquarters.



BIGHORN SHEEP
Ovis canadensis

With mountain and desert forms in N. America, males use their impressive horns to establish a dominance hierarchy. Only the high ranking males secure access to females.

76–112 cm
30–44 in



79–109 cm
31–43 in

DALL SHEEP
Ovis dalli

Creamy white or brown, with curved yellowish horns, dall sheep live in the subarctic mountains of Canada and Alaska.

90–107 cm
35–42 in

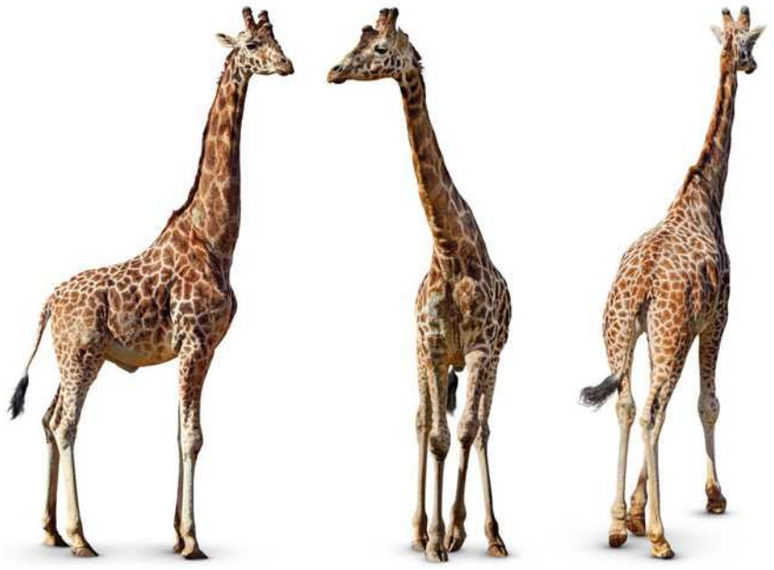
SNOW SHEEP
Ovis nivicola

With pale wool and dark legs, this Siberian sheep is extremely agile and can move rapidly over rough, mountainous terrain.

ROTHSCHILD'S GIRAFFE

Giraffa camelopardalis rothschildi

A subspecies of the northern giraffe, Rothschild's giraffes live in small, single-sex groups. Females often move from one group to another whereas adult males may be solitary. The sexes interact only to mate, the female producing a single calf after a gestation period of about 450 days. Calves are usually weaned at about 12 months. A giraffe's movement is restricted to walking and galloping – giraffes cannot trot or swim. When walking, the front and back legs on the same side move forward at the same time, and an adult can cover about 4.5 m (15 ft) in just one stride. When galloping away from predators, such as lions and African wild dogs, giraffes can reach speeds of up to 55 kph (34 mph).



SIZE 1.5–1.7 m (5–5½ ft)
HABITAT Open woodland, savanna grassland
DISTRIBUTION South Sudan, Kenya, and Uganda
DIET Leaves, shoots, seeds, and fruits of trees

the ossicones have a bald tip in adult males, but are covered with tufts of black hair in females

large, mobile ears keep giraffes alert to their surroundings

^ EYE
The large eyes on the side of the head have excellent vision. This, combined with the giraffe's height, allows them to spot predators while they are still some distance away.

v NOSTRIL
The nostrils can close to prevent debris from entering the nasal passages during sand and dust storms, and act as a barrier to ants while feeding.

TAIL >
The tail can be up to 2.5 m (8 ft) long, and the tuft of black hair at its tip is used to deter insects.

< CURLED TONGUE
The prehensile tongue and upper lip can pluck buds from between the thorns of a tree as well as strip a branch of its leaves.

^ SKIN
Dark skin patches have large sweat glands that help maintain a constant body temperature by dissipating heat.

FOOT >
Each elongated leg ends in a foot with a cloven hoof that has two weight-bearing digits.

giraffes have a good sense of smell

dark coloration is thought to prevent the tongue being sunburned while feeding

ossicones are skin-covered, horn-like bony outgrowths from the skull

the longer, coarser hairs on the chin and nose have specialized sensory nerve receptors

coloured skin patches vary in size and shape, and tend to darken with age in males

short, upright mane extends down the back of the neck from the ears to the shoulders

^ AT FULL STRETCH
A long neck, head, and tongue allow a giraffe to browse from trees that few other mammals can reach, thereby reducing competition for food. Having a long face also helps protect the eyes from thorns while feeding.

> HEAD
All giraffes have two ossicones that are soft at birth but gradually harden as calcium builds up. Male Rothschild's giraffes develop a third smaller ossicone on their forehead.

GIRAFFES AND OKAPI

Diverse in the fossil record, the Giraffidae is represented now by just five species from sub-Saharan Africa. Although giraffes live in a different habitat to the okapi, they share some common features, including a long, dark tongue, ossicones (horns) covered in skin, and lobed canine teeth. Otherwise they resemble the bovids, with cloven hoofs, a four-chambered stomach, and the incisors (upper front teeth) replaced by a horny pad.

1.5–1.7 m
5–5½ ft

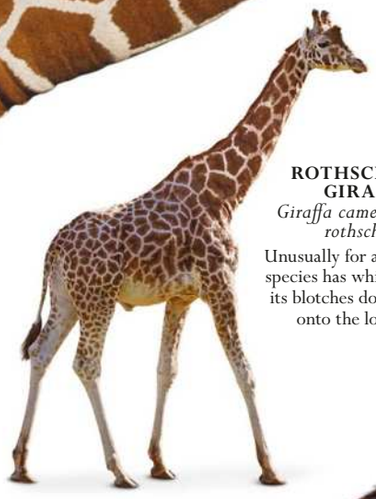
OKAPI
Okapia johnstoni
Restricted to the rainforests of C. Africa, the okapi's long neck and flexible blue tongue show clear similarities to those of giraffes.

short horns covered in skin

large ears

short upright mane

short body with sloping back



1.5–1.7 m
5–5½ ft

ROTHSCHILD'S GIRAFFE
Giraffa camelopardalis rothschildi
Unusually for a giraffe, this species has white "socks" – its blotches do not extend onto the lower leg.

2.7–3 m
8¾–10 ft

MASAI GIRAFFE
Giraffa tippelskirchi
With a neck up to 2.4 m (7¾ ft) long on top of the shoulder height, giraffes are the world's tallest mammals.

2.7–3 m
8¾–10 ft

irregular blotches

ANGOLAN GIRAFFE
Giraffa giraffa angolensis
One of two subspecies of southern giraffe, the Angolan giraffe is found in Namibia, Zambia, Botswana, and Zimbabwe.

RETICULATED GIRAFFE
Giraffa reticulata
Ranging from northern Kenya to Ethiopia, this species of giraffe has large polygonal blotches, often with pale centres, on a pale background.

CAMELS AND RELATIVES

Unique within their order, members of the family Camelidae have just two toes, but no hoofs. Each toe has a small nail at its tip and a soft footpad, which can shift slightly to help maintain grip in mountainous terrian and prevent sinking in soft sand. They also have distinctive teeth, oval red blood cells, a three-chambered stomach, and a leg musculature that means they lie down resting on their knees.

1.8–2 m
6–6½ ft

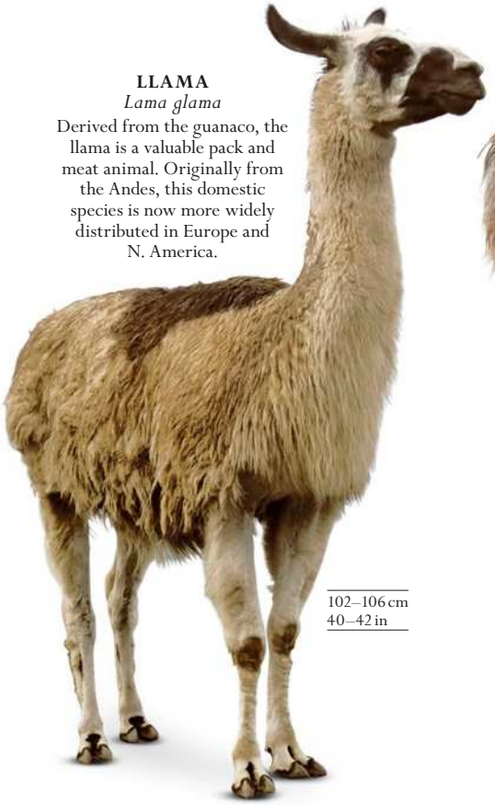
DROMEDARY
Camelus dromedarius
Used for transport in arid regions, this Arabian species is supremely adapted to desert life. Only the feral Australian populations show wild characteristics.

1.8–2 m
6–6½ ft

BACTRIAN CAMEL
Camelus bactrianus
This two-humped camel has been widely domesticated. The wild species, *Camelus ferus*, is restricted to critically small populations in the Asian deserts.

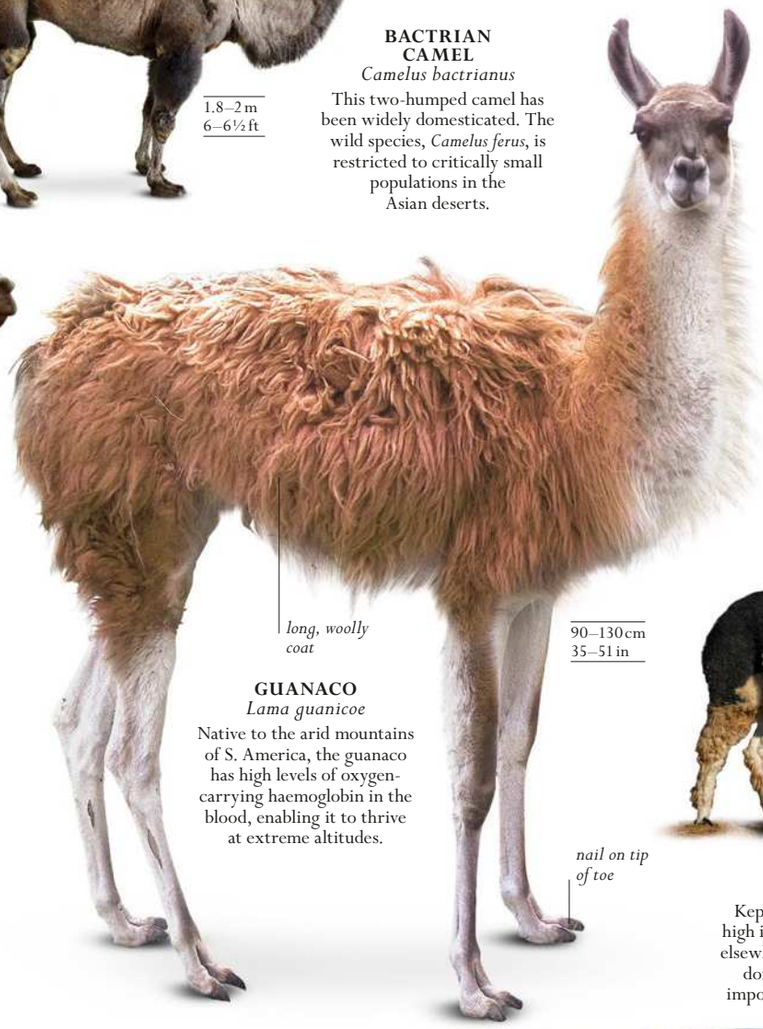
85–90 cm
34–35 in

VICUÑA
Vicugna vicugna
The smaller of the two wild Andean camelids, the vicuña produces a fine wool, which led to its domestication and development of the alpaca.



102–106 cm
40–42 in

LLAMA
Lama glama
Derived from the guanaco, the llama is a valuable pack and meat animal. Originally from the Andes, this domestic species is now more widely distributed in Europe and N. America.



GUANACO
Lama guanicoe
Native to the arid mountains of S. America, the guanaco has high levels of oxygen-carrying haemoglobin in the blood, enabling it to thrive at extreme altitudes.

85–90 cm
34–35 in

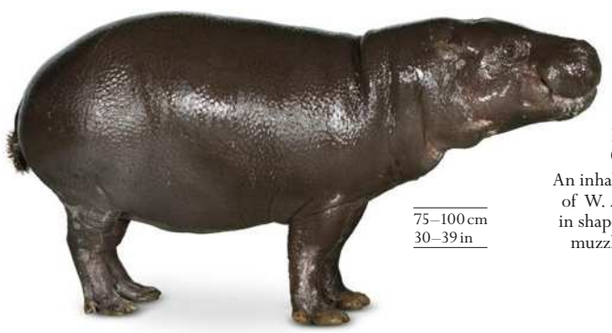
ALPACA
Vicugna pacos
Kept in herds that graze high in the Andes, and now elsewhere in the world, this domestic species is an important source of wool.

HIPPOPOTAMUSES

Among the Artiodactyla, the family Hippopotamidae is unique in that its members walk on four toes on each foot. They also have a huge, barrel-shaped body, short but stout legs, and a large head. Their wide mouth, with tusk-like canine teeth, is used in feeding, fighting, and defence. Reflecting an amphibious lifestyle, the nostrils and eyes are on the top of the snout and the skin is smooth, lacking sweat glands.

1.5–1.65 m
5–5½ ft

COMMON HIPPOPOTAMUS
Hippopotamus amphibius
A solitary nocturnal grazer and sociable daytime wallower, this species is now found mainly in eastern and southern Africa.



75–100 cm
30–39 in

PYGMY HIPPOPOTAMUS
Choeropsis liberiensis
An inhabitant of the forested swamps of W. Africa, this species is similar in shape to its larger relative, but its muzzle is proportionally smaller.

BACTRIAN CAMEL
Camelus bactrianus

The Bactrian camel is an exceptionally hardy animal, built to survive in the harsh desert landscapes of southern Asia, where temperatures range between 40°C (104°F) in summer and -29°C (-20°F) in winter. Camels are adapted to travel long distances over difficult terrain in search of food – such as grasses, leaves, and shrubs – which is scarce. When water is available, the Bactrian camel is able to gulp more than 100 litres (26 gallons) in 10 minutes. It can also survive by drinking salty water if necessary. Almost all of the world's Bactrian camels are domesticated; fewer than 1,000 animals remain in the wild, in remote and inhospitable parts of China and Mongolia. While the genetic status of the two domestic species of camel has long been established, the wild two-humped camel has only recently been recognized as a separate species, *Camelus ferus*, based on molecular genetic data.

closable nostrils keep sand out
small, furry ears
thick fur keeps the camel warm, and also protects it from sunburn
shaggy mane

SIZE 1.8–2 m (6–6½ ft)
HABITAT Stony desert, steppe, and rocky plains
DISTRIBUTION Asia
DIET Herbivorous

∨ EYELASHES
Two rows of extra-thick eyelashes protect the eyes from strong sunlight, and windblown sand and grit, saving precious water from being blinked away as tears.

∨ KNEE PADS
Camels rest on their knees, with their legs folded beneath them. The knees are protected by thick pads of skin.

∧ TEETH
Camels swallow their food whole, then regurgitate and rechew it to aid digestion. Starving individuals have been known to eat rope and leather, which are hard to break down.

∧ MOBILE LIPS
Each half of the split upper lip can be controlled independently, which probably helps them browse thorny vegetation effectively without using their tongues and, thereby, losing moisture.

< ∧ FEET
The feet each have two toes and a tough padded sole that allows the camel to cope equally well with sharp stony ground, hot sand, or compacted snow.

humps contain reserves of fat
distinctive second hump
elbow pad
belly needs little protection from sunburn, so the coat here is thin, allowing heat to be shed
knee pad
paired toes

^ DESERT TRAVELS
Camels are long-legged nomads, able to travel 50 km (30 miles) a day and go without water for a week or more. This extraordinary resilience makes them ideal beasts of burden in arid areas. Bactrian camels eat a wide range of plant foods, and have a large stomach with three chambers in which tough food is slowly broken down. In undernourished camels, the humps become floppy as the reserves of fat are used up.

WHALES, PORPOISES, AND DOLPHINS

Collectively known as cetaceans, this group of mammals is wholly aquatic and all but six species in the order are found in coastal and marine waters.

Supremely adapted to life in water, the cetacean body is tapered and streamlined, with the forelimbs modified into flippers. There are no visible hind limbs, but the tail has horizontal flukes for added propulsion. Many species also have a dorsal fin. The skin is almost hairless and the body is insulated by a layer of blubber, which is especially thick in species living in cold water.

BREATHING AND COMMUNICATING

Capable of diving to great depths and for long periods because of their ability to store oxygen in their muscle tissues, cetaceans must come to the surface to breathe. Breathing is through nostrils, known as blowholes, which are located on the top of the head. When stale air is expelled, it may create a spout of condensation – the spout's size, angle, and shape can be used to distinguish some species, even when their body is almost fully submerged.

Most species produce sound. Some use a series of clicks for echolocation. The clicks bounce off nearby objects, alerting them to any obstacles on their path. Others communicate with each other using vocalizations that range from whistles and groans to the complex songs of many great whales. While their hearing is good, the ears are reduced to simple openings behind the eyes. External ears are both undesirable – they would affect streamlining – and unnecessary, since water is an effective medium for sound transmission.

HUNTER OR FILTER-FEEDER

Cetaceans are divided into two main groups based on their feeding habits. Toothed species, predators of fish, large invertebrates, seabirds, seals, and sometimes smaller cetaceans, catch prey with their sharp teeth and usually swallow it whole, without chewing. In contrast, filter-feeding baleen whales have fibrous baleen plates suspended from their upper jaw that act like sieves. Water, containing invertebrates and mall fish, is taken in and then forced out through the plates by the tongue, leaving behind the organisms.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CETACEA
FAMILIES	14
SPECIES	About 90

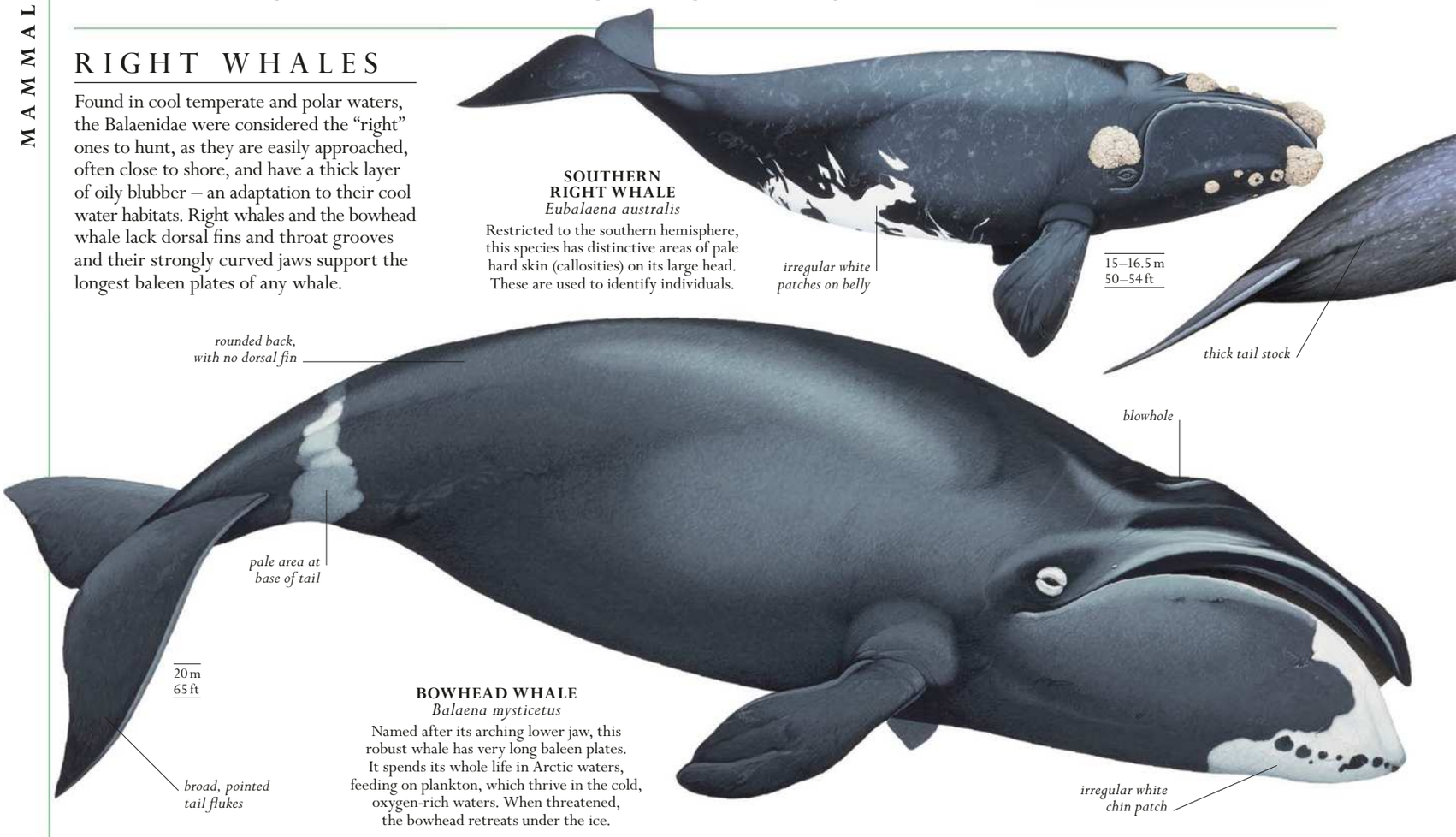
DEBATE

LAND-LIVING ANCESTORS

The taxonomic position of cetaceans has long been debated; their extreme adaptation to a wholly aquatic lifestyle masks anatomical features shared with other orders. Today it is generally accepted that Cetacea is most closely related to Artiodactyla – specifically the hippopotamus family – and so they are grouped together as Cetartiodactyla, at order or superorder level. Evidence comes mainly from genetic and molecular studies, but there is increasing anatomical support, including strong similarities between the ankle bones of artiodactyls and some fossil ancestors of whales.

RIGHT WHALES

Found in cool temperate and polar waters, the Balaenidae were considered the "right" ones to hunt, as they are easily approached, often close to shore, and have a thick layer of oily blubber – an adaptation to their cool water habitats. Right whales and the bowhead whale lack dorsal fins and throat grooves and their strongly curved jaws support the longest baleen plates of any whale.



SOUTHERN RIGHT WHALE
Eubalaena australis

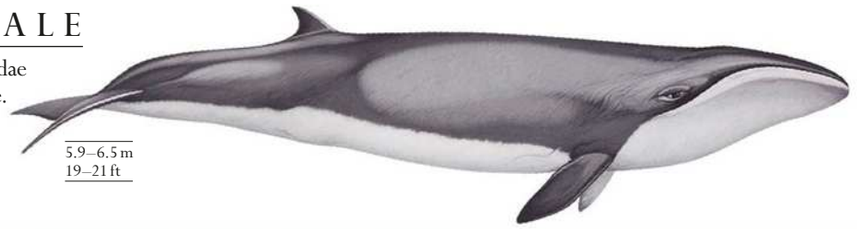
Restricted to the southern hemisphere, this species has distinctive areas of pale hard skin (callosities) on its large head. These are used to identify individuals.

BOWHEAD WHALE
Balaena mysticetus

Named after its arching lower jaw, this robust whale has very long baleen plates. It spends its whole life in Arctic waters, feeding on plankton, which thrive in the cold, oxygen-rich waters. When threatened, the bowhead retreats under the ice.

PYGMY RIGHT WHALE

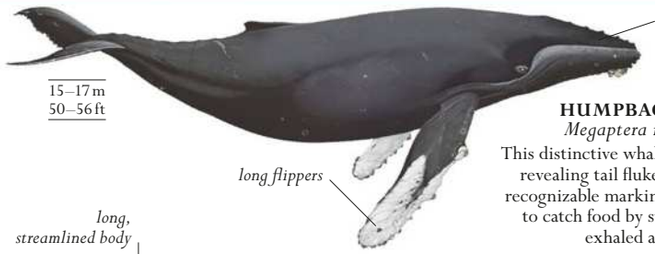
Consisting of one species, the family Neobalaenidae is confined to waters in the southern hemisphere. Unlike true right whales, the pygmy right whale has a small, prominent dorsal fin, but no callosities on the head. Its baleen plates are ivory in colour.



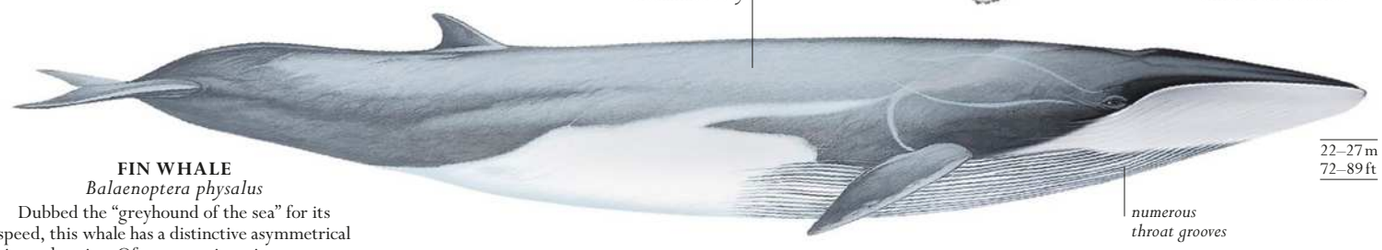
PYGMY RIGHT WHALE
Caperea marginata
The smallest baleen whale, this species is poorly known because of its sparse population. It has short flippers and a weakly arched jaw.

RORQUALS

The largest family of baleen whales, rorquals are named after the Norwegian word for "furrow whale". The furrows on their throat enable them to expand the mouth while filter-feeding. Most of the Balaenopteridae breed in temperate waters, moving to polar feeding grounds in summer. Slender and streamlined, they have long flippers and a dorsal fin set towards the rear of the body.

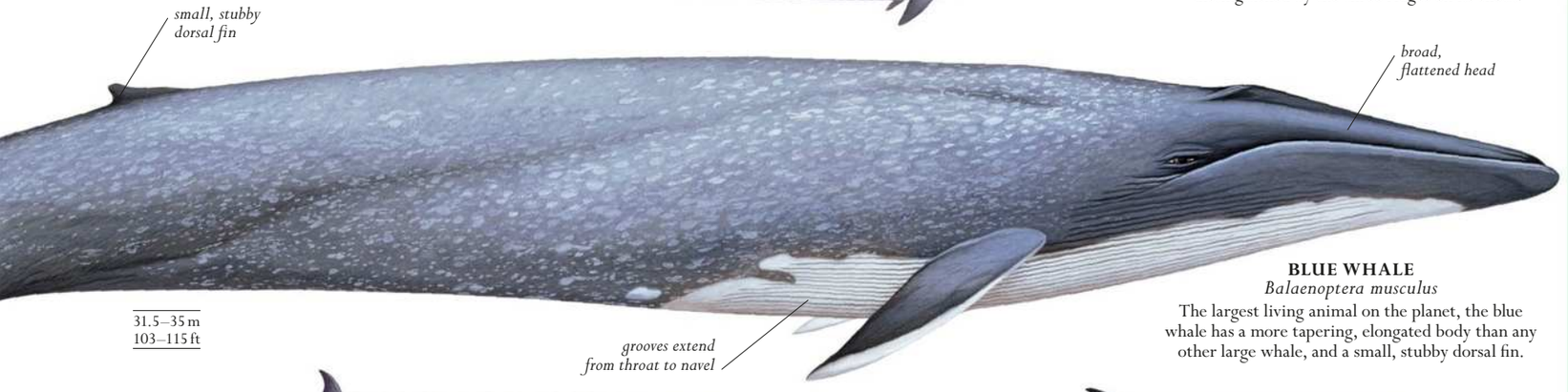


HUMPBACK WHALE
Megaptera novaeangliae
This distinctive whale is very active, often revealing tail flukes with individually recognizable markings. It may bubble net to catch food by surrounding it with exhaled air bubbles.

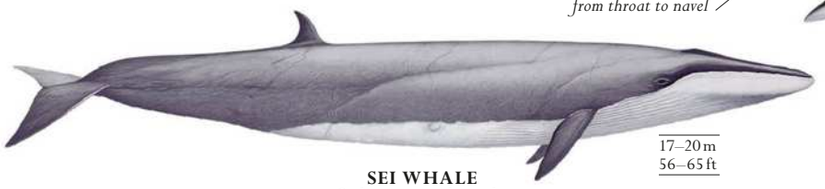


FIN WHALE
Balaenoptera physalus
Dubbed the "greyhound of the sea" for its speed, this whale has a distinctive asymmetrical jaw coloration. Often gregarious, it can occur in groups of up to six or more.

BRYDE'S WHALE
Balaenoptera edeni
Found in shallow tropical and subtropical waters around the globe, this whale is distinguished by the three ridges on its snout.



BLUE WHALE
Balaenoptera musculus
The largest living animal on the planet, the blue whale has a more tapering, elongated body than any other large whale, and a small, stubby dorsal fin.

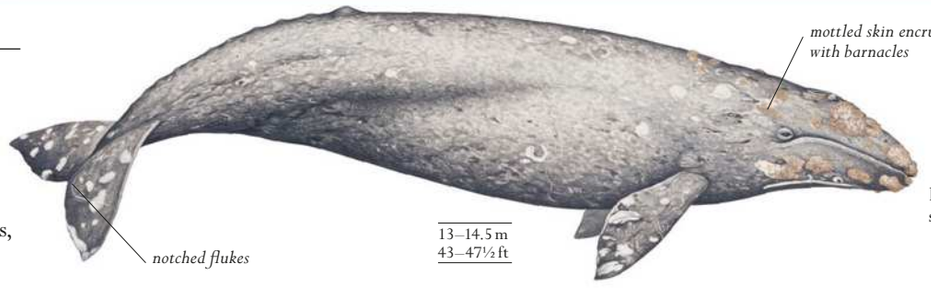


SEI WHALE
Balaenoptera borealis
Mainly found in temperate waters, the sei whale is a fast-moving rorqual. Dark grey above and pale below, it has a more upright, curved dorsal fin.

MINKE WHALE
Balaenoptera acutorostrata
The smallest rorqual, this species has a pointed snout, with a prominent ridge running from the blowhole. Its flippers usually show white patches.

GRAY WHALE

The sole species in the family Eschrichtiidae is now restricted to the eastern North Pacific, having been hunted to extinction in the Atlantic. It undertakes vast annual migrations – the longest of any mammal – from the Bering Sea to breed in subtropical waters, especially off Baja California, Mexico.



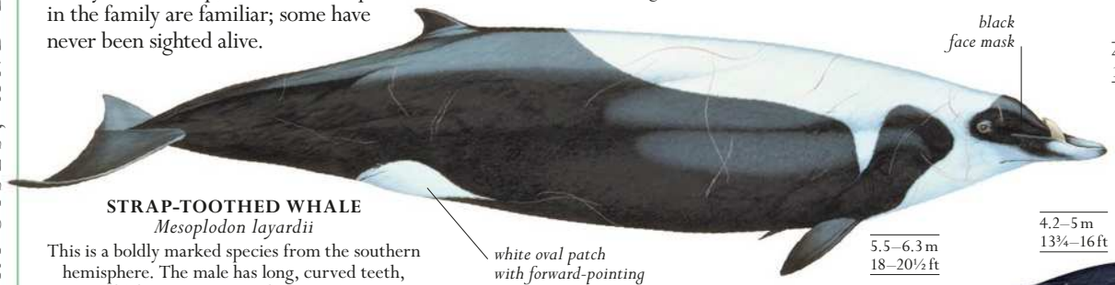
GRAY WHALE
Eschrichtius robustus
Lacking a dorsal fin, the Gray whale's back has a low hump, with a series of smaller "knuckles" behind. The throat grooves are poorly developed.

BEAKED WHALES

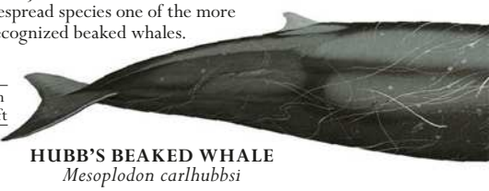
The Ziphiidae are found in the open ocean, typically in small groups that congregate around underwater canyons. They feed near the sea floor, diving for an hour or more. Their facial beak usually has one or two pairs of teeth, which are for display only – food is simply sucked in. Because of their remote habitat and ability to dive deep, few of the 22 species in the family are familiar; some have never been sighted alive.

GRAY'S BEAKED WHALE
Mesoplodon grayi
Found throughout the southern hemisphere, this is one of the few beaked whales with numerous teeth. Its long, slender beak is often whitish.

BLAINVILLE'S BEAKED WHALE
Mesoplodon densirostris
An arched lower jaw and flattened forehead make this widespread species one of the more easily recognized beaked whales.

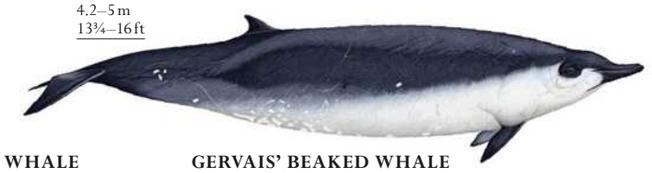


STRAP-TOOTHED WHALE
Mesoplodon layardii
This is a boldly marked species from the southern hemisphere. The male has long, curved teeth, which can meet over the upper jaw.



HUBB'S BEAKED WHALE
Mesoplodon carlhubbsi
Presumed to inhabit the North Pacific, but rarely seen, this species has white patches on its beak and head. The male has two prominent teeth.

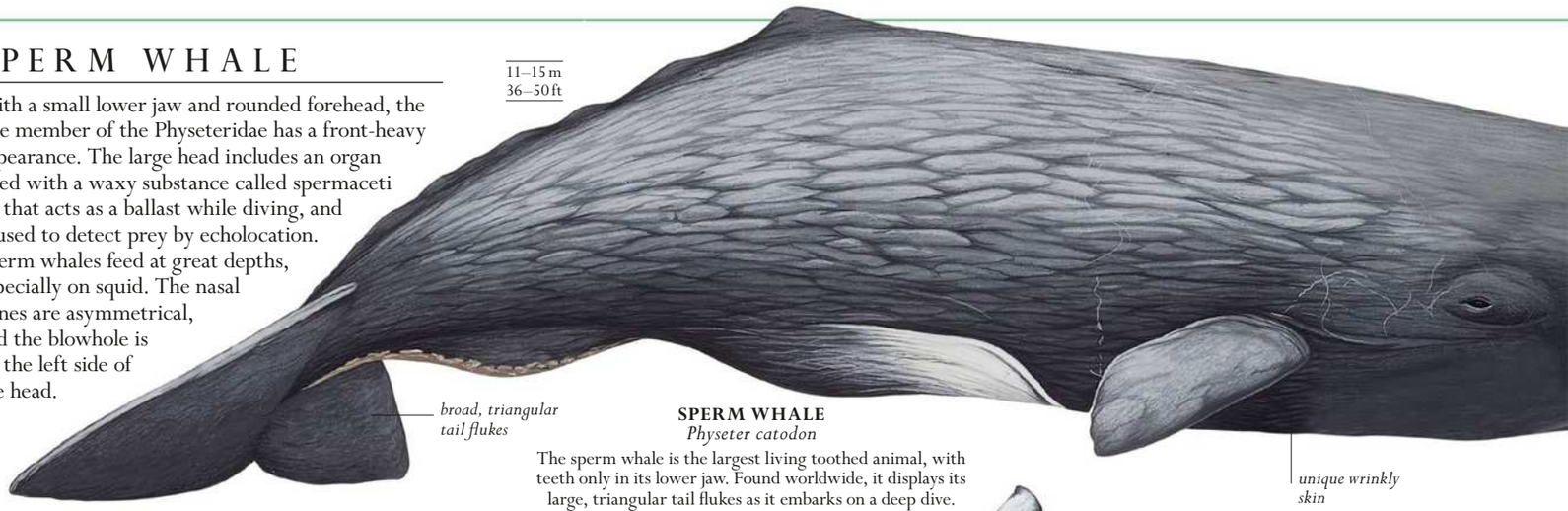
GINKGO-TOOTHED BEAKED WHALE
Mesoplodon ginkgodens
This species is known mainly from strandings (washing ashore on beaches) in the Pacific and Indian oceans. The males have distinctively broad, triangular teeth.



GERVAIS' BEAKED WHALE
Mesoplodon europaeus
This slender whale is seen most often around the Canary Islands in the Atlantic Ocean. The male's teeth are small and at the tip of the beak.

SPERM WHALE

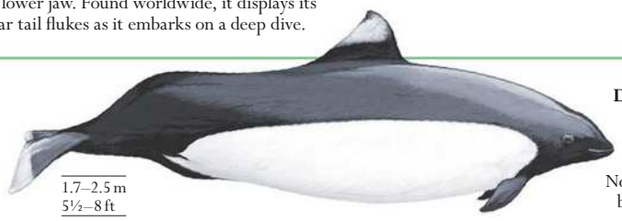
With a small lower jaw and rounded forehead, the sole member of the Physeteridae has a front-heavy appearance. The large head includes an organ filled with a waxy substance called spermaceti oil that acts as a ballast while diving, and is used to detect prey by echolocation. Sperm whales feed at great depths, especially on squid. The nasal bones are asymmetrical, and the blowhole is on the left side of the head.



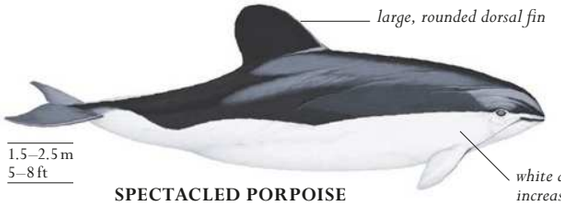
SPERM WHALE
Physeter catodon
The sperm whale is the largest living toothed animal, with teeth only in its lower jaw. Found worldwide, it displays its large, triangular tail flukes as it embarks on a deep dive.

PORPOISES

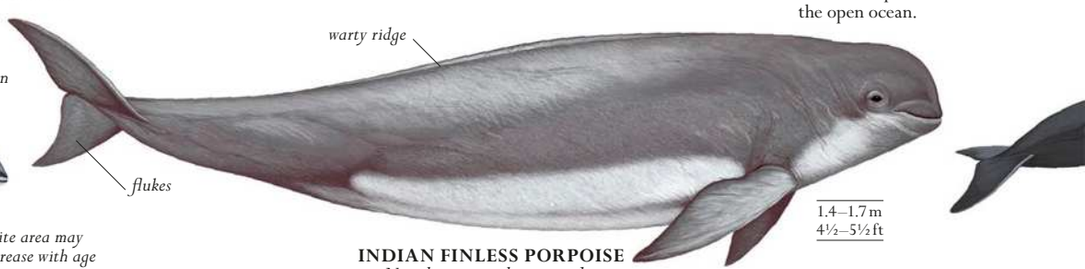
Generally smaller but stouter than dolphins, the Phocoenidae have a small, rounded head and blunt jaws. The dorsal fin is triangular rather than curved. Most distinctively, porpoises have flattened, spade-shaped teeth. Active predators of fish, squid, and crustaceans, porpoises use sound to find prey and communicate. The seven species occur mainly in shallow coastal waters.



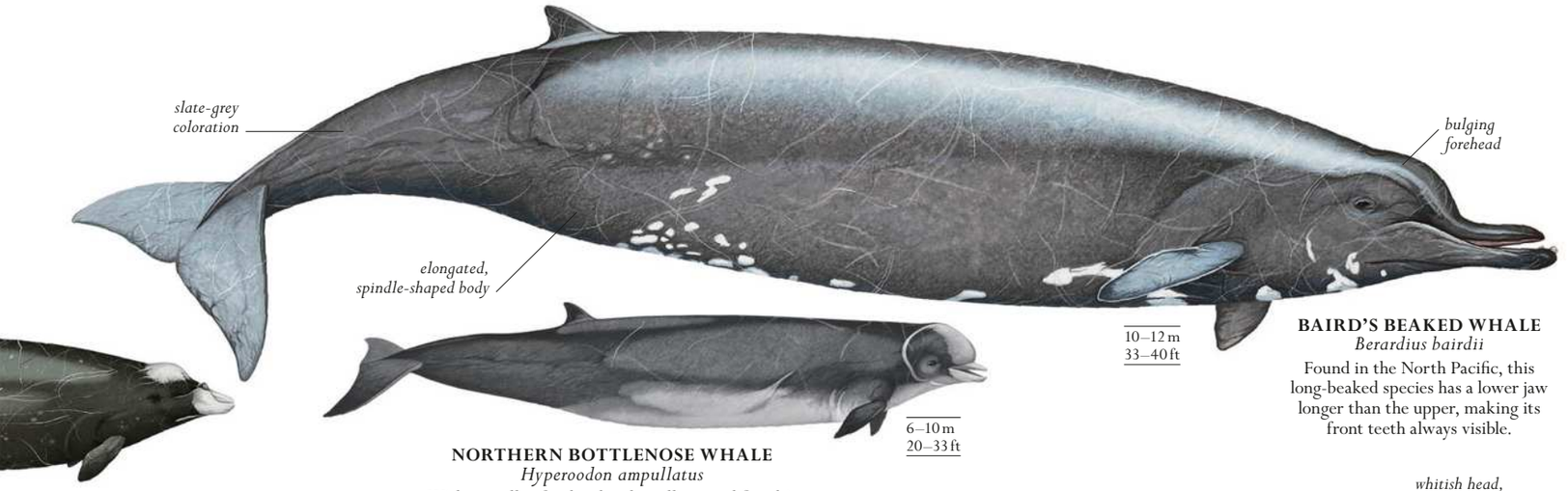
DALL'S PORPOISE
Phocoenoides dalli
This highly active porpoise from the North Pacific has a stout, bicoloured body and a small head. It prefers the open ocean.



SPECTACLED PORPOISE
Phocoena dioptrica
Although rarely seen in its sub-Antarctic range, this species is readily recognized by its sharply demarcated colours. The upper blue-black skin makes it difficult to see from above.

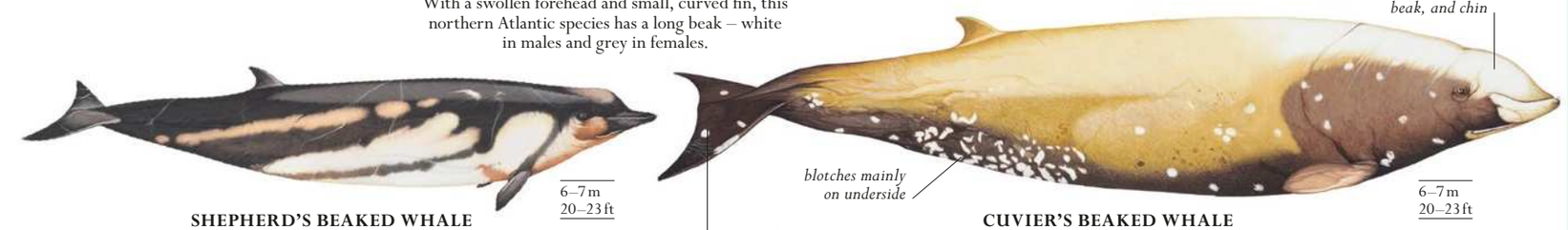


INDIAN FINLESS PORPOISE
Neophocaena phocaenoides
Found throughout Asian coastal waters, including a freshwater population in China, this porpoise has a low warty ridge instead of a dorsal fin.



BAIRD'S BEAKED WHALE
Berardius bairdii
Found in the North Pacific, this long-beaked species has a lower jaw longer than the upper, making its front teeth always visible.

NORTHERN BOTTLENOSE WHALE
Hyperoodon ampullatus
With a swollen forehead and small, curved fin, this northern Atlantic species has a long beak – white in males and grey in females.



SHEPHERD'S BEAKED WHALE
Tasmacetus shepherdi
Known mainly from strandings in Australasia and S. America, this species has a diffused creamy body pattern and numerous small teeth.

CUVIER'S BEAKED WHALE
Ziphius cavirostris
Found worldwide, this whale has a shorter beak than others in the family. It is variable in colour, with a whitish head and back.

PYGMY AND DWARF SPERM WHALES

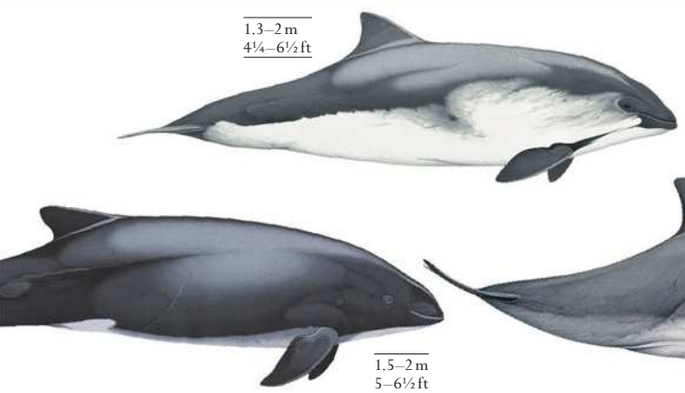
The Kogiidae are small whales with a strongly recurved dorsal fin. They have a characteristic pale, crescent-shaped marking behind each eye that looks rather like the gill opening of a shark.

PYGMY SPERM WHALE
Kogia breviceps
One of the smallest whales, this species is an inhabitant of deep temperate and tropical waters. It is known mainly from strandings.

NARWHAL AND BELUGA

The Monodontidae form a small family of two medium-sized Arctic whales that are rather unusual in appearance. They are highly gregarious species and are found in bays, estuaries, and fjords, and along the edges of pack ice, sometimes in herds of several hundred. Neither species has a true dorsal fin; both have a swollen, rounded forehead, which can change shape when they produce sounds, of which they have a wide range.

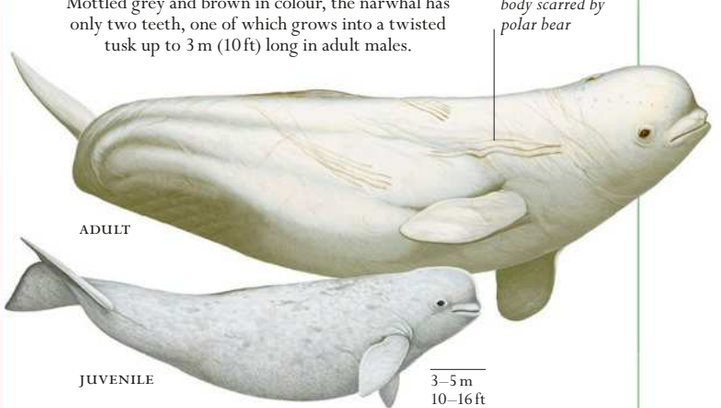
NARWHAL
Monodon monoceros
Mottled grey and brown in colour, the narwhal has only two teeth, one of which grows into a twisted tusk up to 3 m (10 ft) long in adult males.



HARBOUR PORPOISE
Phocoena phocoena
Widespread across the northern hemisphere, the harbour porpoise is one of the most familiar cetaceans. Often found in estuaries, it sometimes ventures upriver.

BURMEISTER'S PORPOISE
Phocoena spinipinnis
This dark porpoise, with a distinctive backward-pointing dorsal fin, is one of the most abundant cetaceans around the coasts of S. America.

VAQUITA
Phocoena sinus
Unique to the Sea of Cortéz (Gulf of California), this is the smallest and rarest porpoise, often inhabiting lagoons so shallow that its back protrudes above the surface.



BELUGA
Delphinapterus leucas
The beluga has a circumpolar distribution in Arctic and subarctic waters, spending the winter around and under pack ice. Uniquely, it is entirely white as an adult.

OCEANIC DOLPHINS

Found worldwide, often in shallow seas over continental shelves, the Delphinidae typically have a curved dorsal fin, protruding beak, and swollen forehead. Small- to medium-sized, their colours and patterns vary widely. Most mainly eat fish and travel in herds or "pods". Larger species are collectively known as blackfish.

1.6–1.9 m
5¼–6¼ ft

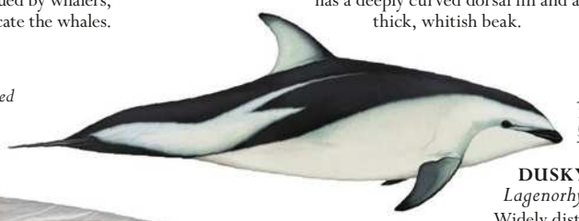
HOURGLASS DOLPHIN
Lagenorhynchus cruciger
Rarely seen, this sub-Antarctic dolphin has two white flank lobes. It frequently associates with fin whales, and was valued by whalers, who used the dolphins to locate the whales.

2.4–3.1 m
7¾–10 ft

WHITE-BEAKED DOLPHIN
Lagenorhynchus albirostris
Highly acrobatic, this North Atlantic species frequently rides the bow wave of boats. It has a deeply curved dorsal fin and a thick, whitish beak.

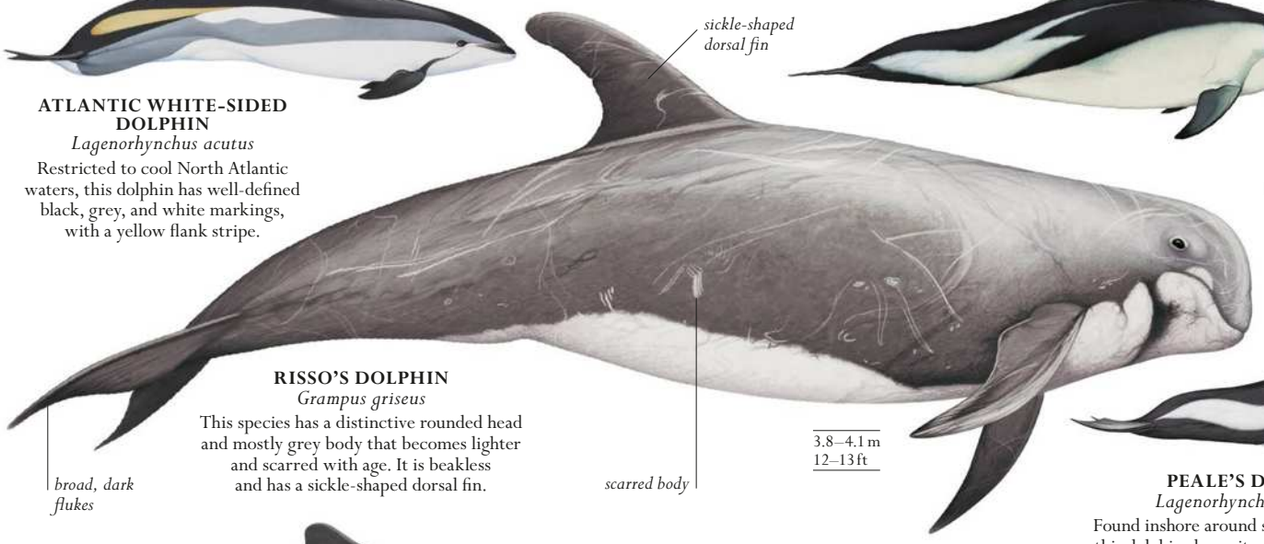
2.5–2.8 m
8–9¼ ft

ATLANTIC WHITE-SIDED DOLPHIN
Lagenorhynchus acutus
Restricted to cool North Atlantic waters, this dolphin has well-defined black, grey, and white markings, with a yellow flank stripe.



1.6–2.1 m
5¼–7 ft

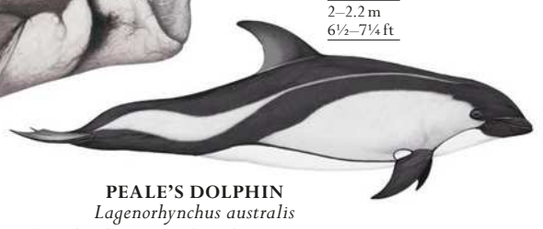
DUSKY DOLPHIN
Lagenorhynchus obscurus
Widely distributed in coastal waters across the southern hemisphere, this is a gregarious and highly acrobatic dolphin, frequently leaping as it feeds.



3.8–4.1 m
12–13 ft

RISSO'S DOLPHIN
Grampus griseus
This species has a distinctive rounded head and mostly grey body that becomes lighter and scarred with age. It is beakless and has a sickle-shaped dorsal fin.

2–2.2 m
6½–7¼ ft

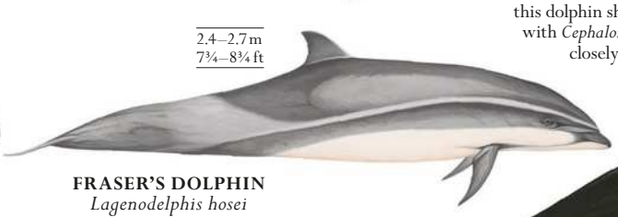


PEALE'S DOLPHIN
Lagenorhynchus australis
Found inshore around southern S. America, this dolphin shares its white "armpit" patch with *Cephalorhynchus* species, and may be closely related to that genus.

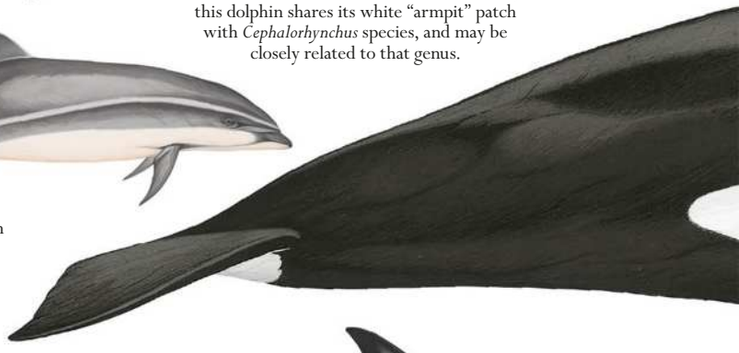
1.5 m
5 ft

COMMERSON'S DOLPHIN
Cephalorhynchus commersonii
A small, piebald, beakless dolphin from the waters around southern S. America and the Indian Ocean, this excellent swimmer and jumper has broad, blunt tail flukes.

2.4–2.7 m
7¾–8¾ ft

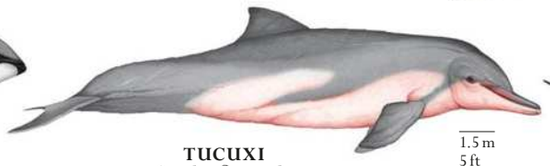


FRASER'S DOLPHIN
Lagenodelphis hosei
This highly gregarious species is found in deep water in the southern hemisphere. Its flippers, fin, and beak are small in proportion to its stocky body.



1.4–1.5 m
4½–5 ft

HECTOR'S DOLPHIN
Cephalorhynchus hectori
Found only in New Zealand waters, Hector's dolphin is the smallest member of its family. It has a rounded dorsal fin with an undercut rear margin.



1.5 m
5 ft

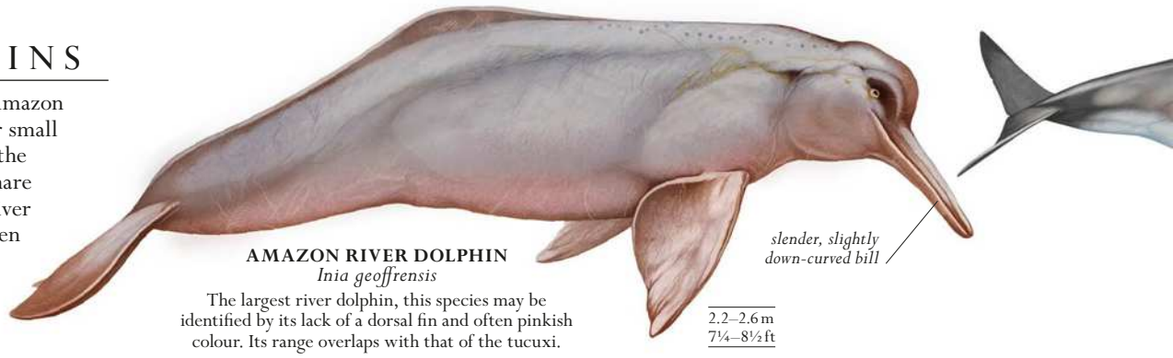
TUCUXI
Sotalia fluviatilis
Although inhabiting rivers in the Amazon basin, the tucuxi is related to oceanic species, not true river dolphins. It resembles a small bottlenose dolphin.

1.6–2.3 m
5¼–7½ ft

SHORT-BEAKED COMMON DOLPHIN
Delphinus delphis
Often forming large groups, this dolphin has a characteristic hourglass flank pattern, which can be easily seen when it leaps out of the water.

RIVER AND ESTUARINE DOLPHINS

The family Iniidae comprises three species of Amazon river dolphin, which can be recognized by their small eyes, bulging forehead, and a long beak, as can the Franciscana of the family Pontopriidae. They share their long, slender beak with the South Asian river dolphin, although their teeth are not visible when the mouth is closed.



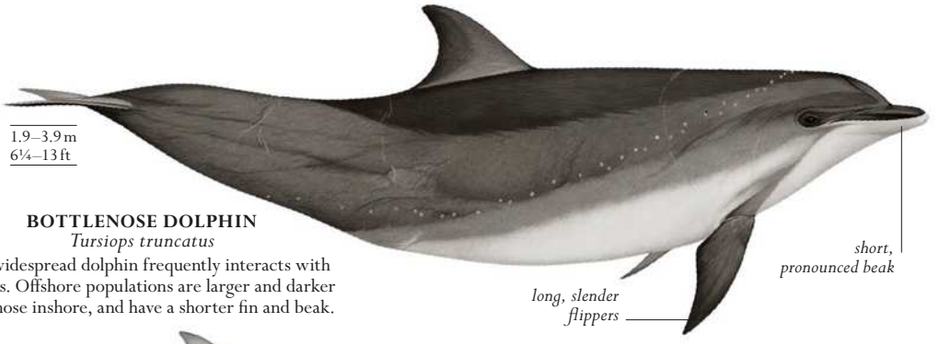
2.2–2.6 m
7¼–8½ ft

AMAZON RIVER DOLPHIN
Inia geoffrensis
The largest river dolphin, this species may be identified by its lack of a dorsal fin and often pinkish colour. Its range overlaps with that of the tucuxi.

2.6–2.8 m
8½–9¼ ft

ROUGH-TOOTHED DOLPHIN
Steno bredanensis

Occurring in most warm waters, this species has a conical head that extends into a long, slender beak, and a broad-based, pointed dorsal fin.



1.9–3.9 m
6¼–13 ft

BOTTLENOSE DOLPHIN
Tursiops truncatus

This widespread dolphin frequently interacts with humans. Offshore populations are larger and darker than those inshore, and have a shorter fin and beak.

1.9–2.3 m
6¼–7½ ft

ATLANTIC SPOTTED DOLPHIN
Stenella frontalis

From the tropical and subtropical Atlantic, this dolphin has dark spots below and pale spots above. These increase in density as it matures.

2.2–2.6 m
7¼–8½ ft

STRIPED DOLPHIN
Stenella coeruleoalba

Found in temperate and tropical parts of all oceans, this acrobatic species has a distinctive pattern of blue stripes and wedges.

3 m
10 ft

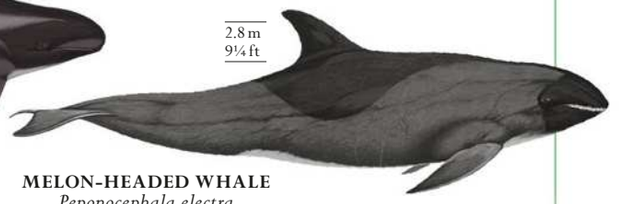
SOUTHERN RIGHT WHALE DOLPHIN
Lissodelphis peronii

Within its range, the only dolphin to lack a dorsal fin, this distinctive black and white species occurs throughout the cool oceans of the southern hemisphere.

5.1–6.1 m
16½–20 ft

FALSE KILLER WHALE
Pseudorca crassidens

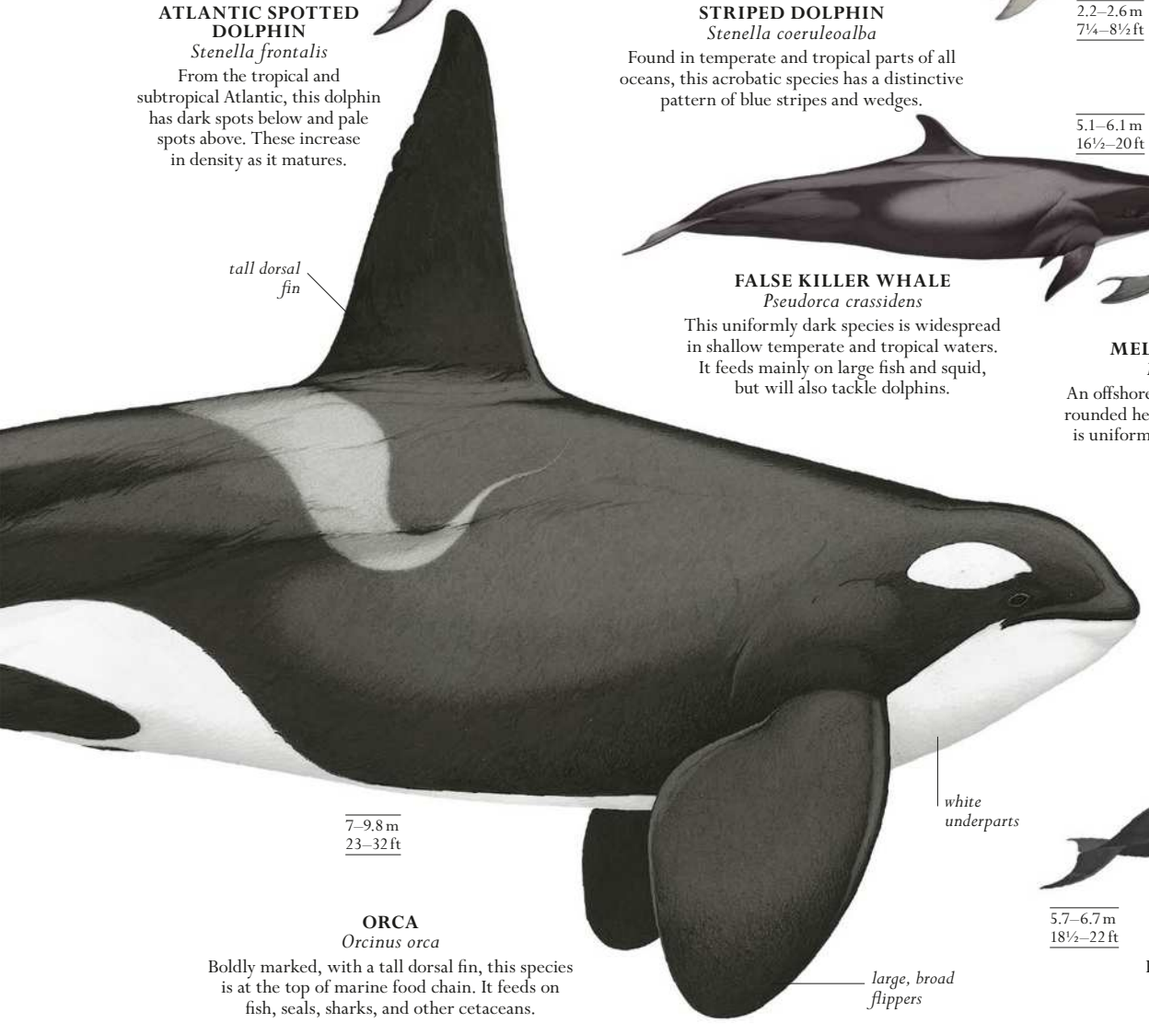
This uniformly dark species is widespread in shallow temperate and tropical waters. It feeds mainly on large fish and squid, but will also tackle dolphins.



2.8 m
9¼ ft

MELON-HEADED WHALE
Peponocephala electra

An offshore tropical species, this whale has a rounded head and a tall, pointed dorsal fin. It is uniformly grey, with a darker face mask.



7–9.8 m
23–32 ft

ORCA
Orcinus orca

Boldly marked, with a tall dorsal fin, this species is at the top of marine food chain. It feeds on fish, seals, sharks, and other cetaceans.

2.1–2.6 m
7–8½ ft

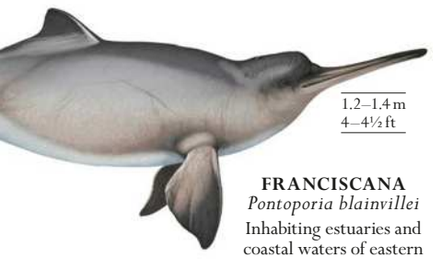
PYGMY KILLER WHALE
Feresa attenuata

Lacking a beak, this small, dark, robust species can be very aggressive. It kills and eats other dolphins within its circumtropical range.

5.7–6.7 m
18½–22 ft

LONG-FINNED PILOT WHALE
Globicephala melas

Prone to mass stranding, this sociable species is widespread in temperate waters. Its bulbous forehead can be seen as it lifts its head out of the water to look around.



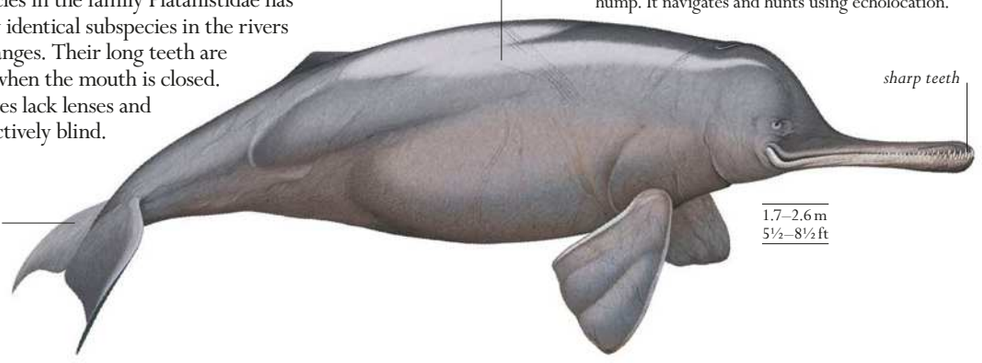
1.2–1.4 m
4–4½ ft

FRANCISCANA
Pontoporia blainvillei

Inhabiting estuaries and coastal waters of eastern S. America, this species has, proportionally, the longest beak of any cetacean at 15 per cent of its total body length.

SOUTH ASIAN RIVER DOLPHIN

The sole species in the family Platanistidae has two virtually identical subspecies in the rivers Indus and Ganges. Their long teeth are visible even when the mouth is closed. Their tiny eyes lack lenses and they are effectively blind.



1.7–2.6 m
5½–8½ ft

SOUTH ASIAN RIVER DOLPHIN
Platanista gangetica

From grey to pale blue to brown, this dolphin has a distinctive long beak, large flippers, and triangular dorsal hump. It navigates and hunts using echolocation.

GLOSSARY

ABDOMEN
The hind part of the body. The abdomen lies below the ribcage in mammals, and behind the thorax in arthropods.

ACCESSORY FRUIT
A fruit that is formed from the flower's ovary and another structure, such as the swollen base of the flower. Examples of accessory fruits are apples and figs.

ADIPOSE FIN
A small fin behind the dorsal fin of a fish. It is mostly fatty tissue covered with skin.

AGARIC
Mushroom-like fruitbody of a fungus, consisting of stem and cap.

ALKALOID
Bitter, sometimes poisonous, chemical produced by certain plants or fungi.

ALLUVIAL (DEPOSIT)
Concentrations of material that have been separated by weathering from the host rock, then deposited in rivers or streams.

AMPHIBOLE
Group of common rock-forming minerals, often with complex composition. Most are ferro-magnesian silicates.

ANAL FIN
The unpaired fin of a fish on the lower side of its body, behind the anus.

ANGIOSPERM
A seed-producing plant that encloses its seeds in a fruit and produces flowers. *See also* gymnosperm.

ANNUAL
A plant that completes its life cycle, from germination to death, in a single season of growth.

ANTENNA (PL. ANTENNAE)
A sensory feeler on the head of arthropods and some other invertebrates, such as molluscs. Antennae are always present in pairs, and can be sensitive to touch, sound, heat, and taste. Their size and shape varies widely according to the way in which they are used.

ANTHER
In flowering plants, the pod-like structure on the stamen that produces pollen.

ANTLER
A bony growth on the head of deer. Unlike horns, antlers often branch, and in most cases they are grown and shed every year in a cycle linked with the breeding season.

ARBOREAL
Living fully or partly – known as semi-arboreal – in trees.

ASCUS (PL. ASCI)
Microscopic sac-like structure of sac fungi (Ascomycota) that produces spores.

ASEXUAL REPRODUCTION
A form of reproduction that involves just one parent, producing offspring that are genetically identical to each other (clones). It is most common in microbes, plants, and invertebrates.

BALEEN
A fibrous substance used by some whales for filtering food from water. Baleen grows in the form of plates with frayed edges, which hang from a whale's upper jaw. The baleen plates trap food, which the whale then swallows.

BASAL ANGIOSPERMS
Five orders of flowering plants with certain primitive features that diverged away from the main evolutionary line of flowering plants before others. Includes water lilies.

BASIDIUM (PL. BASIDIA)
Microscopic club-like structure of mushrooms and relatives (Basidiomycota) that produces spores.

BEAK
A set of narrow protruding jaws, usually without teeth. Beaks have evolved separately in many groups of vertebrates, including birds, tortoises, and some whales. The beak of a bird is also called a bill.

BERRY
A fleshy many-seeded fruit of a plant that develops from a single ovary. Many fruits popularly called berries are not true berries but compound fruits – an example of which is raspberry.

BIENNIAL
A plant that completes its life cycle, from germination to death, in two years. It typically stores up food in the first season that can be used for reproduction in the second season.

BIOLUMINESCENCE
The production of light by living organisms.

BIPEDAL
An animal that moves on two legs.

BRACKET
Shelf-like fruitbody of a fungus.

BRACT
Modified leaf, often brightly coloured, beneath a flower or flower cluster.

BROMELIAD
Flowering plant of the family Bromeliaceae. Almost exclusively tropical American, most live as rainforest epiphytes: perched in the rainforest branches without getting nourishment from the trees. Many form rosettes of leaves that collect rainwater, forming tree-top pools that are important nurseries of insect larvae and frog tadpoles.

BROWSER
An animal that feeds on the leaves of trees and shrubs rather than on grasses.

BULB
The underground shoot of a plant, consisting of modified leaves and used for food storage during periods of dormancy or for asexual reproduction.

CAECUM
Pouch of the digestive tract, often used in the digestion of plant food.

CALYX
Outer cup-like whorl of a flower, made up of sepals.

CAMOUFLAGE
Colours or patterns that enable an animal to merge with its background. It is often used for protection against predators and for concealment when approaching prey.

CANINE (TOOTH)
In mammals, a tooth with a single sharp point that is shaped for piercing and gripping prey. Canine teeth are located toward the front of the jaws, and are highly developed in carnivores.

CARAPACE
A hard shield on the back of some animals, including crustaceans, arachnids, and some reptiles. In turtles and tortoises, the carapace is the upper part of the shell.

CARBOHYDRATE
Foodstuff, such as sugar or starch, that provides energy.

CARNASSIAL (TOOTH)
In mammalian carnivores, a blade-like upper premolar and lower molar tooth that have evolved for slicing through flesh.

CARNIVORE
Any animal that eats meat. The word carnivore can also be used in a more restricted sense to mean mammals of the order Carnivora.

CARPEL
Female reproductive part of a flower, divided into ovary, style, and stigma. Also known as the pistil.

CARTILAGE
A rubbery substance forming part of vertebrate skeletons. In most vertebrates, it lines the joints, but in cartilaginous fish it forms the whole skeleton.

CATKIN
Hanging cluster of flowers, usually with simple flowers all of the same sex.

CELL
The smallest unit of an organism that can exist on its own.

CELLULOSE
A complex carbohydrate found in plants. It is used by plants as building material, and has a resilient chemical structure that animals find hard to digest. Plant-eating animals break it down in their stomach with the aid of micro-organisms.

CHITIN
A tough carbohydrate making up cell walls of fungi and certain animal exoskeletons.

CHLOROPHYLL
Green pigment found in chloroplasts used to trap light energy in photosynthesis.

CHLOROPLAST
Granule inside the cell of a photosynthesizing eukaryote used for photosynthesis. *See* photosynthesis.

CHROMOSOME
Microscopic filament inside a cell that carries genetic information (DNA).

CLIMBER
A plant that grows up a vertical surface, such as a rock or a tree, using it for support. Climbers do not gain nourishment from other plants, but may weaken them by blocking out light.

CLOACA
An opening towards the rear of the body that is shared by several body systems. In some vertebrates – such as bony fish and amphibians – the gut, kidneys, and reproductive systems all use this opening, mainly for waste.

CLONES
Genetically identical individuals. Two or more identical organisms that share exactly the same genes.

CLOVEN-HOOFED
Having hoofs that look as though they are split in half. Most cloven-hoofed mammals, such as deer and antelope, actually have two hoofs, arranged on either side of a line that divides the foot in two.

COCOON
A case made of open, woven silk. Many insects spin a cocoon before they begin pupation, and many spiders spin one to hold their eggs.

COLONY
A group of animals belonging to the same species that spend their lives together, often dividing up the tasks involved in survival. In some colonial species, particularly aquatic invertebrates, the colony members are permanently fastened together. In others, such as ants, bees, and wasps, members forage for food independently but live in the same nest.

COMMENSAL
Living in close relationship with another species without either helping it or damaging it.

COMPOUND
A substance made up of two or more elements chemically reacted together.

COMPOUND EYE
An eye that is divided into separate compartments, each with its own set of lenses. The number of compartments the eye can contain varies from a few dozen to thousands. Compound eyes are a common feature of arthropods.

COMPOUND LEAF
A leaf with a blade divided into smaller leaflets. *See also* simple leaf.

CONE
The reproductive structure of a plant consisting of a cluster of scales or bracts used for producing spores, ovules, or pollen. Cones are found on various trees, particularly pine trees.

CORM
The underground storage organ of a plant, formed from a swollen stem base.

COROLLA
Inner whorl of a flower made up of petals.

CRYPTIC (COLORATION)
Coloration and markings that make an animal hard to see against its background.

CRYSTAL
A solid that has a definite internal atomic structure, producing a characteristic external shape and certain physical and optical properties.

CYTOPLASM
The jelly-like interior of a cell. In the cells of eukaryotes it is restricted to the region around the nucleus.

DECIDUOUS
A plant that seasonally loses its leaves. For instance, many temperate plants lose their leaves in winter.

DELAYED IMPLANTATION
In mammals, a delay between the fertilization of an egg and the subsequent development of an embryo. This delay allows birth to occur when conditions, such as food availability, are favourable for raising young.

DNA (DEOXYRIBONUCLEIC ACID)
The chemical substance found in the cells of all living organisms that determines their inherited characteristics.

DICOTS (DICOTYLEDONS)
Group of flowering plants with two cotyledons (seed leaves).

DIOECIOUS
A plant that has male and female parts on different individuals.

DOMESTICATED
An animal that lives fully or partly under human control. Some such animals look identical to their counterparts in the wild, but many have been bred to produce artificial varieties not found in nature.

DORSAL FIN
The unpaired fin of a fish on the back of its body.

ECHOLOCATION
A method of sensing nearby objects by using pulses of high-frequency sound. Echoes bounce back from obstacles and other animals, allowing the sender to build up a picture of its surroundings. It is used by some bats, cave-dwelling birds, and toothed whales.

ECLIPSE PLUMAGE
In some birds, particularly waterfowl, an unobtrusive plumage adopted by the males once the breeding season is over.

ECOSYSTEM
A collection of species living in the same habitat, together with their physical surroundings.

ECTOPARASITE
An organism that lives parasitically on the surface of another organism's body. Some animal ectoparasites spend all their lives on their hosts, but many – including fleas and ticks – develop elsewhere and climb onto the host in order to feed.

ECTOTHERMIC
Having a body temperature that is dictated principally by the temperature of the surroundings. Ectothermic is also known as cold-blooded.

ELEMENT
Chemical substance that cannot be broken down into a simpler chemical form.

EMBRYO
A young animal or plant at a rudimentary stage of development.

ENDEMIC
A species native to a particular geographic area, such as an island, forest, mountain, state, or country, and which is found nowhere else.

ENDOPARASITE
An organism that lives parasitically inside the body of another organism, either feeding directly on its tissues or stealing some of its food. Endoparasites frequently have complex life cycles involving more than one host.

ENDOSKELETON
An internal skeleton, typically made of bone. Unlike an exoskeleton, this kind of skeleton can grow in step with the rest of the body.

ENDOTHERMIC
Able to maintain a constant, warm body temperature, regardless of external conditions. Also known as warm-blooded.

ENZYME
A group of substances produced by all living things that promotes a chemical process, such as photosynthesis or digestion.

EPIPHYTE
A plant or plant-like organism (such as an alga or lichen) that lives on the body of another plant without getting any nourishment from it.

EUDICOTS (EUDICOTYLEDONS)
Any one of the higher dicot flowering plant orders that together contain the majority of flowering plants.

EUKARYOTE
An organism whose cells have a nucleus. Protoctists, fungi, plants, and animals are eukaryotes.

EVAPORITE (DEPOSIT)
Sedimentary rock or mineral resulting from the evaporation of water from mineral-bearing fluids, usually sea water.

EVERGREEN
A plant that does not lose its leaves seasonally, such as a conifer.

EXTERNAL FERTILIZATION
In reproduction, a form of fertilization that takes place outside the female's body, usually in water, for example in most fish.

EXOSKELETON
An external skeleton that supports and protects an animal's body. The most complex exoskeletons, formed by arthropods, consist of rigid plates that meet at flexible joints. This kind of skeleton cannot grow, and has to be shed and replaced at periodic intervals.

FERAL
An animal that comes from domesticated stock but which has subsequently taken up life in the wild. Examples include city pigeons, cats, and horses.

FERTILIZATION
The union of an egg cell and sperm, which creates a cell capable of developing into a new organism.

FLAGELLUM (PL. FLAGELLA)
A whip-like structure of a cell used for propulsion. It is the main structure of locomotion in flagellate protoctists.

FLOWER
Reproductive structure of the largest group of seed plants, typically consisting of sepals, petals, stamens, and carpels.

FOOD CHAIN
A series of organisms, each of which is eaten by the next.

FOSSIL
Any record of past life preserved in Earth's crust. Fossils include bones, shells, footprints, excrement, and burrows.

FRUIT
A fleshy structure of a plant that develops from the ovary of the flower and contains one or more seeds. Fruits can be simple, like berries, or compound, where the fruits of separate flowers are merged. *See also* accessory fruit.

FRUITBODY
Fleshy spore-producing structure of a fungus, typically in the shape of a mushroom (agaric) or bracket.

GALL
A tumour-like growth in a plant that is induced by another organism (such as a fungus or an insect). By triggering the formation of galls, animals provide themselves with a safe hiding place and a convenient source of food.

GAMETE
A sex cell. In animals, this is either a sperm cell or an unfertilized egg cell.

GENE
The basic unit of heredity in all living things, typically a segment of DNA that provides the coded instructions for a particular protein.

GERMINATION
Developmental stage where a seed or a spore begins to grow.

GESTATION (PERIOD)
Length of time from fertilization to birth in a live-bearing animal.

GILL
In fish, amphibians, crustaceans, and molluscs, an organ used for extracting oxygen from water. Unlike lungs, gills are out-growths of the body. In fungi, gills are the blade-like spore-producing structures under the cap of agaric fungi.

GRAZER
An animal that feeds on grass or algae.

GYMNOSPERM
A seed plant that doesn't enclose its seeds in a fruit. Many gymnosperms carry their seeds on cones. *See also* angiosperm.

HERB (HERBACEOUS PLANT)
A non-woody plant, usually much shorter than shrubs or trees.

HERBIVORE
An animal that feeds on plants or algae.

HERMAPHRODITE
An organism that has both male and female sex organs.

HIBERNATION
A period of dormancy in winter. During hibernation, an animal's body processes drop to a low level to conserve energy.

HORMONE
A chemical signal produced by one part of the body that changes the behaviour of another part of the body.

HORN
In mammals, a pointed growth on the head. True horns are hollow, and are often curved.

HOST
An organism on or in which a parasite, or symbiont, feeds.

HYDROTHERMAL VEIN
Sheet-shaped mass of material altered or deposited by water heated by igneous activity in rock.

HYPHA (PL. HYPHAE)
Microscopic thread-like structure making up the body of a fungus. Many such hyphae make up a mass that is known as a mycelium.

IGNEOUS ROCK
Rock formed from erupted volcanic lava or solidified magma.

INCISOR (TOOTH)
In mammals, a flat tooth at the front of the jaw that is shaped for slicing or gnawing.

INCUBATION
In birds, the period when a parent sits on the eggs and warms them, allowing them to develop. Incubation periods range from under 14 days to several months.

INFLORESCENCE
A flower cluster or a single flower.

INORGANIC
Chemical substance that is not based on the element carbon.

INSECTIVORE
An animal that feeds on insects.

INTERNAL FERTILIZATION
In reproduction, a form of fertilization that takes place inside the female's body. Internal fertilization is a characteristic of many land animals, particularly insects and vertebrates.

KEEL
In birds, an enlargement of the breastbone that is anchored to the muscles that are used in flight.

KERATIN
A tough structural protein found in hair, claws, and horns.

LARVA (PL. LARVAE)
An immature but independent animal that looks completely different from an adult of the species. A larva develops the adult shape by metamorphosis; in many insects, the change takes place in a resting stage that is called a pupa.

LAVA
Molten rock that has erupted from a volcano, and then hardens.

LEGUME
Plants of the pea family of flowering plants, the Fabaceae. They are important for having root nodules that contain nitrogen-fixing bacteria.

LEK
A communal display area used by male animals (particularly birds) during courtship. The same location is often revisited for many years.

LICHEN
Mutualistic association between a fungus and a photosynthetic alga. From this relationship, the fungus obtains sugars, and the alga obtains minerals.

LIFE CYCLE
The developmental sequence of an organism from gametes (sex cells) to death.

LOCOMOTION
Movement from place to place.

LUSTRE
The shine or look of a mineral due to the reflection of light off its surface.

MAGMA
Rock in a molten state and lying below Earth's surface.

MAGNOLIIDAE
Group of flowering plants consisting of four orders with certain primitive characteristics, such as undifferentiated tepals instead of sepals and petals.

MANDIBLE
The paired jaws of an arthropod, or, in vertebrates, the bone that makes up all or part of the lower jaw.

METABOLISM
The complete array of chemical processes that takes place inside an animal's body. Some of these processes release energy by breaking down food, while others use energy, for example, by making the body's muscles contract.

METAMORPHIC ROCK
Rock that has been changed by heat, pressure, or both to form new rock consisting of new minerals.

METAMORPHOSIS
A change in body shape undergone by many animals – particularly invertebrates – as they grow from being a juvenile to an adult. In insects, metamorphosis can be complete or incomplete. Complete metamorphosis involves a total shape change during a resting stage, which is called a pupa. Incomplete metamorphosis involves a series of less drastic changes, and these occur each time the young animal moults.

MIGRATION
A journey undertaken to a different region, following a well-defined route. Most migratory animals move with the seasons to take advantage of good breeding conditions in one place, and a suitable wintering climate in another.

MIMICRY
A form of camouflage in which an animal resembles another animal or an inanimate object, such as a twig or a leaf. Mimicry is very common in insects, with many harmless species imitating ones that have dangerous bites or stings.

MINERAL
An inorganic, naturally occurring material with a constant chemical composition and regular internal atomic structure.

MITOCHONDRION (PL. MITOCHONDRIA)
Granule inside the cell of a eukaryote used for respiration. Mitochondria use up oxygen to release energy.

MOLAR (TOOTH)
In mammals, a tooth at the rear of the jaw. Molar teeth often have a flattened or ridged surface, and deep roots. They are normally used for chewing.

MONOCOTS (MONOCOTYLEDONS)
Group of flowering plants with a single seed leaf (cotyledon).

MONOECIOUS
A plant that has separate male and female parts on the same individual.

MONOGAMOUS
Mating with a single partner, either during the course of one breeding season or throughout life. Monogamous partnerships are common in animals that care for the development of their young.

MOULT
The shedding of fur, feathers, or skin so that it can be replaced. Mammals and birds moult to keep their fur and feathers in good condition, to adjust their insulation, or so they can be ready to breed. Arthropods, such as insects, moult their exoskeleton in order to grow.

MUTUALISM
A relationship between two different species within an ecological community where both species benefit. For instance, a flowering plant and a pollinating insect share a mutualistic relationship.

MYCELIUM
Mass of thread-like hyphae making up the body of a fungus.

MYCORRHIZA (PL. MYCORRHIZAE)
The mutualistic association between a fungus and the roots of a plant. The fungus obtains sugars, while the plant increases its mineral uptake by absorbing minerals via the fungus's extensive mycelium.

NICHE
An organism's place and role in its habitat. Although two species may share the same habitat, they never share the same niche.

NITROGEN FIXATION
A chemical process whereby atmospheric nitrogen is converted into more complex nitrogen-containing substances, such as protein. Nitrogen fixation is undertaken by certain types of micro-organisms.

NODE
The point where two sections of a plant's stem join, from which one or more leaves, shoots, branches, or flowers arise.

NUCLEUS (PL. NUCLEI)
The structure inside the cell of a eukaryote that contains chromosomes.

NUT
Dry, hard-shelled fruit of some plants, usually a single seed.

NYMPH
An immature insect that looks similar to its parents but which does not have functioning wings or reproductive organs. A nymph develops its adult form by metamorphosis, changing slightly each time it moults.

OMNIVORE
An animal that eats both plants and other animals as its primary food source.

OPERCULUM
A cover or lid. In some gastropod molluscs, an operculum is used to seal the shell when the animal has withdrawn inside. In bony fish, an operculum on each side of the body protects the chamber containing the gills.

OPPOSABLE
Able to be pressed together from opposite directions. For example, many primates have opposable thumbs, which can be pressed against the fingers so objects can be grasped.

ORGAN
The structure of a body that carries out a particular function. Examples are the heart, skin, or a leaf.

ORGANELLE
A specialized structure that forms part of a plant or animal cell.

ORGANIC
Chemical substance based on carbon.

OVIPAROUS
Reproducing by laying eggs.

OVIPOSITOR
An egg-laying tube extending out of the body of some female animals, especially in insects.

OVULE
Structure that contains the egg of a seed plant. These are encased in an ovary in flowering plants, but naked in gymnosperms. After fertilization the ovule becomes the seed.

PARASITE
An organism that lives on or in another host organism, gaining advantage (such as nourishment) while causing the host harm. Most parasites are much smaller than their host and have complex life cycles involving the production of huge numbers of young. Parasites often weaken their host but generally do not kill them.

PARTHENOGENESIS
A form of reproduction in which an egg cell develops into a young animal without having to be fertilized, producing offspring that are genetically identical to the parent. In animals that have separate sexes, young produced by parthenogenesis are always female. Parthenogenesis is common in invertebrates.

PECTORAL FIN
One of the two paired fins positioned toward the front of a fish's body, often just behind its head. Pectoral fins are usually highly mobile and are normally used for manoeuvring.

PELVIC FIN
The rear paired fins in fish, which are normally positioned close to the underside, sometimes near the head but more often towards the tail. Pelvic fins are generally used as stabilizers.

PERENNIAL
A plant that normally lives for more than one season.

PERIANTH
The outer two whorls of a flower (the calyx, made up of sepals, and the corolla, made up of petals); especially where the two are undifferentiated.

PETAL
One of the parts of the corolla of a flower. Petals are often brightly coloured to attract pollinating animals.

PETIOLE
The stalk of a leaf.

PHEROMONE
A chemical produced by one animal that has an effect on other members of its species. Pheromones are often volatile substances

that spread through the air, triggering a response from animals some distance away.

PHOTOSYNTHESIS
A process whereby organisms use light energy to make food and oxygen; photosynthesis occurs in plants, algae, and many micro-organisms.

PLACENTA
An organ developed by an embryo mammal that allows it to absorb nutrients and oxygen from its mother's bloodstream before it is born.

PLANKTON
Floating organisms, many of them microscopic, that drift in open waters, particularly near the surface of the sea. Planktonic organisms can often move, but most are too small to make any headway against strong currents. Planktonic animals are known as zooplankton. Planktonic algae are called phytoplankton.

PLASTRON
The lower part of the shell structure of tortoises and turtles.

POLLEN
Tiny grains produced by seed plants that contain male gametes for fertilizing the female egg of either a flowering plant or a coniferous plant.

POLYGAMOUS
A reproductive system in which individuals mate with more than one partner during the course of a single breeding season.

PREDATOR
An animal that catches and kills other animals, referred to as its prey. Some predators attack and catch their prey by lying in wait, but most actively pursue and attack other animals.

PREHENSILE
Able to curl around objects and grip them.

PREMOLAR (TOOTH)
In mammals, a tooth positioned midway along the jaw between the canine and the molar teeth. In carnivores, specialized premolar teeth act like shears, slicing through flesh.

PROBOSCIS
An animal's nose, or set of mouthparts with a nose-like shape. In insects that feed on fluids, the proboscis is often long and slender, and can usually be stowed away when not in use.

PROKARYOTE
An organism whose cells do not have a nucleus. The Archaea and Bacteria used to be classified as Prokaryota.

PRONOTUM
The part of an insect's cuticle that covers the first segment of its thorax, often hardening into a shell.

PROTEIN
Substance found in food, such as meat, fish, cheese, and beans, that is used for growth and for carrying out a variety of essential biological functions.

PSEUDOPOD
Temporary projection of a cell, such as an amoeba or a white blood cell, which is used for creeping forward or for catching food.

PUPA (PL. PUPAE)
In insects, a stage during which the larval body is broken down and rebuilt as an adult. During the pupal stage the insect does not feed and usually cannot move, although some pupae may wriggle if they are touched. The pupa is protected by a hard case, which itself is sometimes wrapped in silk.

QUADRUPEDAL
An animal that walks on four legs.

RAPTOR
A bird of prey.

RHIZOME
A creeping or underground stem that can send out new shoots.

ROCK
Material made up of one or more minerals.

ROOT NODULE
Spherical swelling on the root of a legume that contains nitrogen-fixing bacteria.

RUMINANT
A hoofed mammal that has a specialized digestive system with several stomach chambers. One of these – the rumen – contains large numbers of micro-organisms which help break down plant food. To speed this process, a ruminant usually regurgitates its food and rechews it, a process called chewing the cud.

SALLY
A bird's short flight from a perch to catch an invertebrate, often in mid-air.

SCUTE
A shield-like plate or scale that forms a bony covering on some animals.

SEDIMENTARY ROCK
Rock formed by the consolidation and hardening of rock fragments, organic remains, or other material.

SEED
Developmental stage of a seed plant, consisting of an encapsulated embryo.

SEPAL
One of the parts of the calyx of a flower, usually small and leaf-like and enveloping the unopened flower bud.

SEXUAL DIMORPHISM
Showing physical differences between males and females. In animals that have separate sexes, males and females always differ, but in highly dimorphic species, such as elephant seals, the two sexes look very different and are often unequal in size.

SHOOT
The aerial part of plant. It is a new growth, usually growing upwards.

SHRUB
Woody perennial plant with multiple stems.

SIMPLE LEAF
A leaf with an undivided blade.

SPERMATOPHORE
A packet of sperm that is transferred either directly from male to female, or indirectly – for example, by being left on the ground. Spermatophores are produced by a range of animals, including salamanders, squid, and some arthropods.

SPIRACLE
In some fish, an opening behind the eye that lets water flow into the gills. In insects and myriapods, the spiracle is an opening on the body wall that lets air into the tracheal system.

SPORE
A single cell containing half the quantity of genetic material of typical body cells. Unlike gametes, spores can divide and grow without being fertilized. Spores are produced by fungi, algae, and plants.

SPOROPHYTE
The spore-producing stage of a plant. It is the dominant (visible) stage of ferns and seed plants.

STAMEN
Male reproductive part of a flower. It has an anther borne on a long filament.

STEREOSCOPIC (VISION)
Vision in which the two eyes face forward, giving overlapping fields of view and allowing the animal to judge distance. Also called binocular vision.

STOMA (PL. STOMATA)
Tiny adjustable pore on the surface of a plant that allows the exchange of gases for photosynthesis and respiration.

SWIM BLADDER
A gas-filled bladder that most bony fish use to regulate their buoyancy. By adjusting the gas pressure inside the bladder, a fish can become neutrally buoyant, meaning that it neither rises nor sinks.

SYMBIOSIS
Any relationship between two different species within an ecological community. Examples of symbiotic relationships are predator–prey, parasite–host, and mutualism.

TEPAL
The outer part of a flower undifferentiated into sepals and petals. Tepals collectively make up the perianth.

TERRESTRIAL
Living wholly or mainly on the ground.

TERRITORY
An area defended by an animal, or group of animals, against other members of the same species. Territories often include resources, such as food supply, that help the male attract a mate.

THORAX
The middle region of an arthropod's body. The thorax contains powerful muscles and, if the animal has any, bears legs and wings. In vertebrates with four limbs, the thorax is the chest.

TORPOR
A sleep-like state in which body processes slow to a fraction of their normal rate. Animals usually become torpid to survive difficult conditions, such as extreme cold or lack of food.

TRACHEAL SYSTEM
A system of minute tubes that arthropods (for example, insects) use to carry oxygen into their bodies. Air enters the tubes through openings called spiracles, and then flows through the tracheae to reach individual cells.

TREE
A woody perennial plant usually with a well-defined stem, or trunk, and a crown of branches above.

UNGULATE
A hoofed mammal.

UTERUS
In female mammals, the part of the body that contains and usually nourishes developing young. In placental mammals, the young are connected to the wall of the uterus via a placenta.

VECTOR
An organism that transmits a disease-causing parasite from one host to another.

VEIL
Thin skin- or web-like tissue that protects the fruitbody of a fungus.

VESTIGIAL
Relating to an organ that is atrophied or non-functional.

VIVIPAROUS
Reproducing by giving birth to live young.

VOLVA
A sac-like remnant of a veil at the base of a fungus's fruitbody stem.

WOODY PLANT
A plant that has wood – a type of strengthening tissue found in plants consisting of thick-walled water-transporting vessels.

ZYGODACTYL FEET
A specialized arrangement of the feet in which the toes are arranged in pairs, with the second and third toes facing forwards and the first and fourth toes facing backwards. This adaptation helps birds to climb and perch on tree-trunks and other vertical surfaces. Several groups of birds have zygodactyl feet, including parrots, cuckoos, turacos, owls, and toucans, woodpeckers, and their relatives.

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